



Africa Research in Sustainable Intensification for the Next Generation

Sustainable intensification of cereal-based farming systems in the
Guinea-Sudano-Savanna of West Africa

2016 Workplan



FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative



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The Africa Research In Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research-for-development projects supported by the United States Agency for International Development as part of the U.S. government's Feed the Future initiative.

Through action research and development partnerships, Africa RISING will create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three regional projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads the program's monitoring, evaluation and impact assessment. <http://africa-rising.net/>



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This document was made possible with support from the American people delivered through the United States Agency for International Development (USAID) as part of the US Government's Feed the Future Initiative. The contents are the responsibility of the producing organization and do not necessarily reflect the opinion of USAID or the U.S. Government.

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Partners

Name	Acronym	Ghana	Mali	Role/responsibility
AfriqueVerte, Mali	¹ AMASSA		+	On-farm and household nutrition studies with ICRISAT.
AGRIMAT Ghana Limited	AGRIMAT	+		Evaluation and supply of post-harvest equipment, e.g. shellers
Association Malienne d'Eveil et de Developpement Durable	¹ AMEDD		+	On-farm field trials/household nutrition studies with ICRISAT
Agricultural Development & Value Chain Enhancement Program	ADVANCE II	+		Assist with market linkages, joint demonstration of technologies
Animal Research Institute	ARI	+		R4D on livestock production (sheep and goats) with ILRI
Agricultural Technology Transfer Project	ATT	+		Assist with the introduction of new labor-saving technologies
The World Vegetable Center	AVRDC	+	+	Lead R4D on vegetable production systems
Community-based Organizations	CBOs	+	+	On-farm implementation of R4D activities
International Center for Tropical Agriculture	CIAT	+		Lead R4D on land and soil management
Centre d'Appui a l' Auto promotion pour le Development	¹ CAAD		+	On-farm groundnut intensification
Le Groupe de Recherches d'Actions et d'Assistance pour le Development Communautaire	¹ GRAADECOM		+	On-farm groundnut intensification
Compagnie Malienne de Developpement des Textiles	CMDT		+	On-farm field trials and household nutrition studies
Crops Research Institute	CRI	+		Breeder seed of improved cereals and legumes
Food Research Institute	FRI	+		Household nutrition
Grains and Legumes Development Board	GLDB	+		Production of foundation seeds
Heifer International	¹ HI	+		On-farm livestock production with IITA
World Agroforestry Center	ICRAF		+	Lead R4D on agroforestry systems
International Crops Research Institute for the Semi-arid Tropics	ICRISAT	+	+	Sorghum/millet-groundnut R4D with IITA and SARI
International Food Policy Research Institute	IFPRI	+	+	Lead site selection, baseline survey and M&E
Institut d'Economie Rurale	IER		+	Socio-economic and on-farm studies with ICRISAT
International Institute of Tropical Agriculture	IITA	+	+	Overall project coordination and R4D research on cereal systems
International Livestock Research Institute	ILRI	+	+	Lead R4D on ruminants in Ghana and MRMs

				governance in Mali
Institute for Scientific and Technological Information	INSTI	+		Organize training and publish project document with IITA
International Water Management Institute	IWMI	+		Lead R4D on water management
Kwame Nkrumah University of Science and Technology	KNUST	+		Graduate student training and R4D on rural pig production
Mouvement Biologique du Mali	¹ MOBIOM		+	On-farm and household nutrition studies with ICRISAT
Ministry of Food and Agriculture	MoFA	+		Scaling-out SI technologies and establishment of R4D platforms
Ministry of Health	MoH	+		Household nutrition R4D with UDS and IITA
Post-Harvest Losses Innovation Laboratory	PHL-IL	+		Joint studies on comparison of grain storage methods/ aflatoxin
Savanna Agricultural Research Institute	SARI	+		R4D on cereal-legume-vegetable systems
Seed Producers Association of Ghana	¹ SEEDPAG	+		Production of certified seeds and training on seed production
Small Scale Irrigation Innovation Laboratory	SSI-IL	+		Testing of small-scale irrigation options and model validation
Soil Research Institute	SRI	+		R4D on integrated soil fertility management with IITA
University for Development Studies	UDS	+		Graduate training and R4D on rural poultry and pig production
University of Ghana	UG	+		Graduate training and post-harvest research
Wageningen University, The Netherlands	WU	+	+	R4D on farming systems characterization and graduate training

¹Non-governmental organization

Introduction

The document presents work plans for the 2015/16 research year, the last of the 5-year project which ends in September 2016. The planned activities for each country are presented under five research themes listed below. Activities under Theme 1 cut across the other themes.

1. Partnerships and socio-economic assessment (Research Theme 1, RT1).
2. Intensification of cropping and integrated crop-livestock systems (Research Theme 2, RT2).
3. Intensive livestock production (Research Theme 3, RT3).
4. Land, soil and water management (Research Theme 4, RT4).
5. Improving nutrition, food storage, value addition and mycotoxin management (Research Theme 5, RT5).

The planned activities focus on field studies to round-up uncompleted trials and/or collect additional data, and analysis of data and publication of results of trials from the previous research years. Consideration is given to some of the short-term recommendations of the USAID commissioned external evaluation team in October 2015. For example, there are plans to develop research strategies for capacity building, nutrition and livestock (RT1-Gh-1.3) with the expectation that a second phase of the project will be funded.

2. Ghana work plan

Theme 1: Partnerships and socio-economic assessment (RT1-Gh)

1. Research team

<i>Name</i>	<i>Institution</i>	<i>Degree</i>	<i>Research interest</i>	<i>Role</i>
Asamoah Larbi	IITA	PhD	Crop-livestock systems	Leader, RT1-Gh-1
Bekele Kotu	IITA	PhD	Agricultural economics	Leader, RT1-Gh-2
Mary Asante	IITA	MSc	Agronomy	Coordinator, Upper West Region
Abdul Nurudeen	IITA	MSc	Agronomy	Coordinator, Northern Region
Stephen Frimpong	IITA	MSC	Agricultural economics	Research Associate
Jeroen Groot	WUR	PhD	Farming systems	Leader, RT1-Gh-3
Gundula Fischer	IITA	PhD	Gender/Sociology	Leader, RT1-Gh-4
Mirja Michalscheck	WUR	MSc	Farming systems	PhD student
Akua Opoku B	UCC	PhD	Consultant	RT1-Gh-4
Shaibu Bedi	WUR	BSc	Agricultural economics	Graduate student
Katrien Descheemaeker	WUR	PhD	Farming systems	RT1-Gh-4

2. Objectives

- 1 Mobilize communities, revise list of beneficiaries and geo-reference participating households
- 2 Assess cost and benefits of SI interventions and monitor adoption of technologies
- 3 Analyze the farming systems and construct typologies
- 4 Mainstream gender into Africa RISING activities

3. Activities

Activity RT1-Gh-1 Mobilize communities and facilitate R4Dplatforms

Lead scientist(s)	Asamoah Larbi	Institution: IITA
Other scientist(s)	Mary Asante, Abdul Nurudeen	
Consultant	To be identified	
Location(s)	Intervention communities in Salvelugu, Tolon/Kunbunu, Bongo, Kassena-Nankana, Wa West and Nadowli districts	

Procedures

Sub-activity RT1-Gh-1.1: Community mobilization and workshops on 2015 activities

Community consultation initiated in 2015 will continue. Community workshops will be organized to document farmers' comments on the 2015 participatory trials. During the workshops the possibilities to include more young women and men as Africa RISING beneficiaries will be discussed.

Sub-activity RT1-Gh-1.2: Facilitation of multi-stakeholder platforms

Identification, interviews and validation of stakeholders will continue at the district and community levels in all the regions. The input demands during the season will be taken into account in recruiting new stakeholders (for example seed producers and marketers). The R4D platforms in the six districts were launched in 2015. Advice will be sought from the Africa RISING project in the Ethiopian Highlands for operationalization and facilitation of the Innovation (IP) and R4D platforms. The district level platforms are strategic and broad, but at the community level the IPs could follow different value chains or other entry points based on farmers' interest.

Deliverables		Date (2016)
1	New stakeholders or actors identified at the community and district levels	Jun
2	Training for platform executive members held by Africa RISING Ethiopia	May

Activity RT1-Gh-2	Economic validation and monitoring adoption of SI options	
Lead scientist(s)	Bekele Kotu	Institution: IITA
Other scientist(s)	Stephen Frimpong, Mary Asante, Abdul Nurudeen, David Wawula, Shaibu Bedi, Gundula Fischer	
Location(s)	Intervention communities in Salvelugu, Tolon/Kunbungu, Bongo, Kassena-Nankan, Wa West and Nadowli districts	

Procedures

Sub-activity RT1-Gh-2.1: Economic validation of selected improved agricultural technologies

The overall objective of this sub-activity is to complement ongoing biophysical studies in the process of maturing agricultural technologies by assessing their economic advantages. It assesses the profitability of the technologies validated by Africa RISING (AR). Three following activities will be undertaken for this season:

- 1) Contribute to publication of results from completed studies: Many trials are at an advanced stage to allow analysis of socio-economic data and their publication. To this effect, we will work together with the scientists responsible for the trials associated with promising technologies.
- 2) For selected technologies which have won farmers' preferences, additional assessments will be conducted based on participatory approaches which will involve farmers of different categories (i.e. beneficiary and non-beneficiary farmers, women, youth). In addition to profitability, in this case, we will look into how the proposed technologies fit into existing conditions of farmers (such as labor requirements, cash requirements, social acceptability of technologies, and gender roles). This will generate evidence that can be used to scale up/out the technologies.

Data collection: Qualitative data such as farmers' opinion on performance of the technologies, expenses associated with the technologies and their distributions over the cropping season, farmers' resource endowments, and potential challenges and opportunities of using the technologies

Sub-activity RT1-Gh-2.2: Monitoring the adoption of Africa RISING technologies

The objective of this study is to assess how well Africa RISING technologies are being adopted by the farmers (reasons for adoption, non-adoption, and dis-adoption). This study will depend mainly on a household survey which involves two rounds of data collection. The first round was conducted in August 2015. Data collection will continue during this implementation period. Thereafter, the data will be analyzed and a report as well as scientific papers will be prepared.

Data collection: Application of inputs (fertilizer, chemicals and labor), input costs, information sources for modern inputs and agricultural practices, crop output, crop output allocations, livestock production, abundance/scarcity of household farm resources (land, labor, cash and farm tools), and comparisons of Africa RISING technologies vs traditional practices

Deliverables

	Date (2016)
1 Cleaned datasets on adoption of selected AR technologies, uploaded to CKAN	May
2 Draft report on the status of use of AR technologies	Jul
3 MSc thesis on the role of gender in the adoption of sustainable intensification practices in Northern Ghana	Sep
4 At least two conference papers	Sep

Activity RT1-Gh-3

Lead scientist(s)	Jeroen Groot	Institution: WUR
Other scientist(s)	Katrien Descheemaeker	
Student(s)	Mirja Michalscheck	
Location(s)	Selected communities in the Northern, Upper East and Upper West regions	

Procedures

This activity will identify possibilities to adjust farms and livelihoods of households for sustainable intensification, and to evaluate the impact of implementation on productive, environmental and social performance indicators using the whole farm model Farm DESIGN. It will also inform the households of available options and their impacts, research findings and involve them in research, reflection and learning cycles. This will be closely related to their livelihood strategies.

Collection of additional farm and household information to complement data gathered during the rapid characterization, the GARBES as well as previous community meetings and interviews. A new element is the focus on intra-household differences in order to better understand adoption patterns within different households. Furthermore, we aim to merge existing farm typologies into a single framework, serving as a basis to evaluate Africa RISING technologies per farm type and per region. This task is performed in close consultation with IFPRI, local AR staff as well as farm communities.

We aim to create a locally specific 'basket of technologies' consisting of potential adjustments to the farms. The basket of technologies primarily contains AR-technologies at Baby trial or Upscale stage since farmers have implemented these on their own fields and are able to evaluate them, adding a social context to the bio-economic assessment in the whole farm model. We perform

an exploration of tradeoffs and synergies among the productive, environmental and social performance indicators on the basis of the current farm configuration and the available options in the basket of technologies.

All activities will be developed in close consultation and discussion with communities and researchers. There will be explicit attention to the existing heterogeneities in socio-economic and bio-physical conditions.

Deliverables		Date (2016)
1	Final report evaluating the different AR technologies per farm type and per region	Apr
2	Models for each farm and each technology package; incl. detailed notes for easy later modification	May
3	Conference paper (Tropentag 2016)	Sep
4	Draft journal article about farm type specific evaluation of technologies	Sep

Activity RT1-Gh-4	Gender analysis of sustainable intensification practices	
Lead scientist(s)	Gundula Fischer	Institution: IITA
Other scientist(s)	Bekele Kotu	
Consultant	B. Akua Opokua (University of Cape Coast, Center of Gender Research, Advocacy and Documentation)	
Location(s)	Selected communities in the Northern, Upper East and Upper West Regions	

Procedures

Since October 2015 a team of gender experts from the University of Cape Coast (in cooperation and under supervision of Gundula Fischer) has conducted a qualitative gender-focused evaluation of Africa RISING's interventions in selected communities in the Northern, Upper West and Upper East regions. Core questions of the evaluation were:

1. Evaluation criteria for new agricultural practices: Which criteria do female/male farmers use when evaluating new agricultural practices for suitability? How can gender differences in evaluation criteria be explained?
2. Adoption of Africa RISING practices: Which Africa RISING practices have been/have not been adopted by male/female farmers? Why have female or male farmers adopted/rejected certain practices and what is the relationship with gender dynamics in terms of labour allocation, income distribution, access to resources and to information as well as other key aspects of gender analysis?
3. Adaptation of Africa RISING practices: Have female/male farmers adapted certain Africa RISING practices to make them more suitable for their use? If yes, how have male versus female farmers adapted these practices for their purposes? Why have they adapted them?
4. Access to information and learning: In each community, what are the most important sources of information and learning about agricultural practices? How do female/male farmers have access to information and participate in learning? How can gender differences in access to information and participation be explained?

The research methodology comprised 12 focus group discussions (including a ranking exercise) with farmers in gender-separate groups and key informant interviews with district directors of agriculture, district agricultural extension agents, Africa RISING community facilitators, Africa RISING R4D platform members and traditional leaders (male, female).

Transcriptions and expanded notes of focus groups discussions and key informant interviews as well as a draft report are available.

In 2016 the following steps will be taken to complete the activity:

- Stakeholder validation of the results
- Inclusion of results from stakeholder validation into the final report
- Publication of final report

Data collection: Qualitative gender analysis

Deliverables	Date (2016)
1 Stakeholder validation completed	May
2 Submission of final report on gender analysis of sustainable intensification practices	Jun
3 Publication of final report on CG space	Sep

Activity RT1-Gh-5	In-country research management	
Lead scientist(s)	Asamoah Larbi	Institution: IITA
Other scientist(s)	Bekele Kotu, Mary Asante, Abdul Nurudeen, Stephen Frimpong	
Consultants	To be identified	
Location(s)	Selected communities in the Northern, Upper East and Upper West regions	

Procedures

Sub-activity RT1-Gh-5.1: Organize regional research team meetings

Regional teams meeting will be organized every 8-12 weeks for local and international partners to discuss problems and share lessons. The meeting will be organized on separate days in each region to allow partners working in more than one region to attend.

Sub-activity RT1-Gh-5.2: Organize exchange visits

Exchange visits will be organized for farmers, researchers and extension staff at the community, district and regional levels. This will allow knowledge and information exchange and joint learning among partners.

Sub-activity RT1-Gh-5.3: Development of livestock, nutrition, post-harvest and capacity building strategies

In response to the recommendations of the USAID commissioned evaluation, strategies for livestock and nutrition research and capacity building will be developed. The strategies will indicate how the livestock and nutrition activities will be link to each other, and to the crop and integrated crop-livestock research and what key capacities need to be built and how for sustainability of the project activities.

Deliverables

1	Regional research team reports completed	Date (2016) Apr, Jun, Aug, Oct, Dec
2	Report on exchange visits at the community, district and regional level	Aug-Oct
3	Nutrition and capacity building strategies completed	Aug

4. Expected outcomes

		Short	Medium	Long
1	Increased interaction among stakeholders through the R4D platforms	x	x	
2	Research institutions use more R4D platforms and less of the linear research-extension approach		x	x
3	Farmers are modifying and adopting technologies		x	x

5. Budget (US\$x1000)

Theme/Activity ¹	Budget Line	IITA	MOFA
RT1-Gh-1	Personnel	15	7
	Services	12	5
	Supplies	8	2
	Travel	15	6
RT1-Gh-2	Personnel		
	Services		
	Supplies		
	Travel		
RT1-Gh-3	Personnel		
	Services		
	Supplies		
	Travel		
RT1-Gh-4	Personnel		
	Services		
	Supplies		
	Travel		
RT1-Gh-5	Personnel	15	
	Services	10	
	Supplies	10	
	Travel	5	
	Total	90	20
	Grand total	110	

¹ Budget for RT1-Gh-2, 3, and 4 is allocated under different arrangement

Theme 2: Intensification of cropping and integrated crop-livestock systems (RT2-Gh)

1. Research team

<i>Name</i>	<i>Institution</i>	<i>Degree</i>	<i>Research interest</i>	<i>Role</i>
Asamoah Larbi	IITA	PhD	Crop-livestock, feeds	Leader, RT2-Gh-1
Saaka Buah	SARI	PhD	Agronomy	Leader, RT2-Gh-2
Jean-Baptiste Tignegre	AVRDC	PhD	Vegetable breeding	Leader, RT2-3
Samuel Adjei-Nsiah	IITA	PhD	Agronomy	Sub-activity RT2-Gh-1.3.4
Ibrahim Dugje	IITA	PhD	Agronomy	Sub-activity RT2-Gh-1.7
I.D.K Atokple	IITA	PhD	Plant breeding	Sub-activity RT2-Gh-1.6
Paul Tanzibul	ICRISAT	PhD	Entomology	Sub-activity RT2-Gh-1.8, 1.9
Abdul Nurudeen	IITA	PhD	Agronomy	Coordinator, Northern Region
Mary Asante	IITA	MSc	Agronomy	Coordinator, Upper West Region
Bekele Kotu	IITA	PhD	Agric. Economics	RT2-Gh-1
Stephen Frimpong	IITA	MSc	Agric. Economics	RT2-Gh-1
Francis Kusi	SARI	PhD	Entomology	RT2-Gh-2
Roger Kanton	SARI	PhD	Agronomy	RT2-Gh-2
Peter Asongre	SARI	PhD	Agronomy	RT2-Gh-2
Issa Suguri	SARI	MSc	Post-Harvest	RT2-Gh-2
Opere Obuobi	SARI	MSc	Plant breeding	RT2-Gh-2
Julius Yirzagla	SARI	MSc	Agronomy	RT2-Gh-2
M Abukari	SARI	MSc	Entomology	RT2-Gh-2
Mumuni Abdulai	SARI	MSc	Entomology	RT2-Gh-2
Theodore Avukpor	KNUST	BSc	Horticulture	MSc student
Mohammed Kadir	KNUST	BSc	Horticulture	MSc student
Jonathan Naaba	KNUST	BSc	Horticulture	MSc student
Iddrisu Bashiru	KNUST	BSc	Horticulture	MSc student
Abdulai Haruna	KNUST	BSc	Agronomy	MSc student
Stella Obani	ATT	MSc	Soil science	Sub-activity RT2-Gh-1.3.4, 1.6
Nana Yaw Obeng	AGRIMAT	MSc	Post-Harvest/Water	RT2-Gh-3

2. Objectives

- 1 Test and disseminate cropping and integrated crop-livestock systems to increase productivity per unit area
- 2 Develop and test integrated soil fertility management options to improve crop yields
- 3 Improve productivity of irrigated and rain-fed vegetable production

3. Activities

Activity RT2-Gh- Intensifying integrated cereal-legume-livestock cropping systems

1

Lead Scientists(s)	Asamoah Larbi	Institution: IITA
Other scientist(s)	Abdul Nurudeen, Mary Asante, Peter Asongre, Bekele Kotu, Stephen Frimpong, Stella Obani, Paul Tanzibul	
Student(s)	Haruna Abdulai	
Locations(s)	All intervention communities	

Procedures

Sub-activity RT2-Gh-1.1: Analyze and publish results from completed experiments

Data from completed trials will be analyzed. Results will be presented at professional meetings and/or published in international peer reviewed journals.

Sub-activity RT2-Gh-1.2: Test and demonstrate improved crops and cropping options in technology parks

Selected on-going 'Mother' trials initiated in the Technology Parks during the 2013/14 and 2014/15 research years will be continued for the third year in 3-4 communities per region.

Sub-activity RT2-Gh-1.3: Evaluate productivity and profitability of cereal-legume strip cropping systems

Trials in Technology Parks and on-farms during the 2013/14 and 2014/15 research years have shown that cereal (maize) and legumes (groundnut, cowpea, and soybean) strip cropping is one of the farmers preferred technologies in northern Ghana. One of the key objectives of strip cropping is to optimize food and feed production without degrading the soil and water resource base. The quantity and quality of crop residues in the various strip cropping systems were not assessed in the previous studies. The effect of managing the crop residues for mulch and feed in the strip cropping systems was also not quantified in the previous studies. Also, early-millet-legume strip cropping systems were not evaluated. The following research questions on cereal-legume strip cropping systems remain unanswered:

- Do the quantity and quality of grain and fodder differ among various cereal-legume strip cropping systems? What will be the effect of managing the crop residues in a strip cropping systems for feed or mulch on grain yield, soil and vegetation resources?
- How profitable are the various cereal-legume strip cropping systems?

A series of on-farm and on-station trials will be implemented to answer the above questions. A split-plot design will be used with 4-6 replications in each trial.

Sub-activity RT2-Gh-1.3.1: Evaluate productivity and profitability of maize-cowpea strip cropping systems

Main-plots (cropping systems)

1. Maize alone (M)
2. Cowpea alone(C)
3. 2M:2C
4. 2M:4C

Sub-plots (residue management)

1. Residue not removed (mulch: soil fertility maintenance)
2. Residue removed (feeding: livestock)

Lead farmers and/or community parks with a land area of at least one acre will be identified. Pre-planting application of paraquat will be done to control emerged weeds when rain is fully established. Ridges, 75cm apart, will be constructed after land preparation. Cereals and legumes will be planted on ridges in the combinations listed above. Participating farmers will be given free inputs (e.g., seeds, fertilizer) for the on-farm trials and technical support to establish their plots. Two maize seeds per hill will be sown at 75cm by 40cm. The recommended dose of NPK fertilizer (60-40-40) will be applied to both maize and legumes strips in 2 split doses. Apply the first dose of 40-40-40kg/ha of NPK 15:15:15 at 10-14 days after sowing. Apply the balance of 20kg N as top dressing at 4 - 5 weeks after sowing. Conduct at least 2 manual hoe weeding or when necessary. Spray the legumes with insecticides to control pest and diseases up to 3 times during the growing season.

Harvest three 2m x 2m plots to estimate total biomass, grain yield and harvest index. After harvest, crop residues from half of the plot will be removed to feed the farmers' sheep and goats, while residues on the other half will be retained as mulch for soil fertility improvement.

Data collection: Biological (grain and fodder yield, weed biomass and diversity), soil chemical and physical properties, and socio-economic (farmer preferences, labour input, gender distribution of chores)

This activity is implemented in collaboration with the ATT project which will be out-scaling cowpea-maize strip cropping at intervention communities outside the Africa RISING intervention communities.

Sub-activity RT2-Gh-1.3.2: Productivity of maize-soybean strip cropping systems

Design and treatments:

Main-plots (cropping systems)

1. Soybean alone (S)
2. Maize alone
3. 2M:2S
4. 2M:4S

Sub-plots (residue management)

1. Residue not removed (mulch: soil fertility maintenance)
2. Residue removed (feeding: livestock)

Procedures will be similar to Sub-activity RT2-Gh-1.3.1. Inoculated seeds of non-shattering soybean will replace cowpea.

Sub-activity RT2-Gh-1.3.3: Productivity of early millet-groundnut strip cropping systems

Main-plots (cropping systems)

1. Early millet (EM)
2. Groundnut (G)
3. 1EM:1G
4. 2EM:2G
5. 2EM:4SG

Sub-plots (residue management)

1. Residue not removed (mulch: soil fertility maintenance)
2. Residue removed (feeding: livestock)

Procedures and data collection will be similar to those outlined in Sub-activity RT2-Gh-1.3.1. Maize will be replaced by early-maturing millet.

Sub-activity RT2-Gh-1.3.4: Scaling-out of maize-legume strip cropping technology

This will be jointly implemented by the Africa RISING, ATT and N2-Africa projects. Two technologies (2 rows of maize:2 rows of legume and 2 rows of maize:4 rows of legume) will be up-scaled based on potentials of these technologies from Africa RISING project findings.

The technologies will be demonstrated in 15 communities of the ATT project across the 3 northern regions using the preferred maize variety. Establishment of the demonstrations, provision of maize seeds and monitoring of the demonstration plots will be funded by ATT. Africa RISING will provide legume seeds and fertilizers, whilst N2-Africa will supply inoculants. Cost of field days will be shared between ATT and Africa RISING.

Sub-activity RT2-Gh-1.5: Sheep stocking density and agronomic practices effects on productivity

The objective is to evaluate the impact of integrating sheep and goat management and agronomic practices on grain yield and soil chemical, biological and physical properties. A split-split-plot design replicated in 3-4 communities in the Upper East Region is used. Main-plots are two sheep/goat management practices (no-corralling, corralling with sheep/goats): 1. No corralling and 2. Corralling with sheep and goats. Sub-plots are two maize planting densities: 1. Recommended density (66,667 plants/ha), and 2. Higher density (133,333 plants/ha).

Data collection: Weed population and density, grain and fodder yields and soil physical, chemical and biological characteristics. Two-year data will be analyzed. A PhD dissertation will be written, and two papers submitted for publication in peer reviewed journals.

Sub-activity RT2-Gh-1.6: Cowpea living mulch effects on intensive maize production

Soils in the three northern Ghana regions are generally low in fertility, especially organic matter, N, P and K resulting in low grain yields. Will the use of living mulch during the maize cropping season affect grain yield and soil properties in northern Ghana? This trial aims at providing information to answer this question. This study will be conducted in collaboration with the ATT and Scaling Cowpea projects to develop integrated soil fertility management strategies for intensive maize production in the Northern and Upper West regions.

Design and treatments

A split-plot design with cowpea leaving mulch as main-plots and maize planting density as subplots with 4-6 replications.

Main-plots

1. No living mulch
2. Trailing cowpea living mulch

Sub-plots

1. Recommended density (66,667 plants/ha) with recommended NPK fertilizer rate
2. 50% higher than the recommended density with recommended NPK fertilizer rate
3. 100% higher than the recommended density with recommended NPK fertilizer rate

Data collection: Growth and biomass yield of maize and cowpea, weed biomass, surface run-off; soil physical (infiltration rate, porosity, temperature, bulk density) and chemical (N, P, K) properties

Sub-activity RT2-Gh-1.7: Leaf stripping to optimize feed from maize-based cropping systems

Feed shortages during the cropping season constrain ruminant production in small-scale crop-livestock production systems in northern Ghana. Leaves stripped from maize plants after silking or cob formation could provide feed during the cropping season without compromising grain yield, but there is limited quantitative data on the practice in Ghana. The objective of this joint Africa RISING/SARD-SC activity will be to determine the effect of leaf-stripping on grain and fodder yields and quality of maize.

Design and treatments

A split-plot design with maize maturity types as main-plots and leaf-stripping as subplots with 4-6 replications.

Main-plots

1. Extra-early maturing maize variety
2. Early maize maturing variety
3. Medium maize maturing variety

Sub-plots

1. Recommended density (66,667 plants/ha) with recommended NPK fertilizer rate
2. 50% higher than the recommended density with recommended NPK fertilizer rate
3. 100% higher than the recommended density with recommended NPK fertilizer rate

Sub-sub-plots

1. No leaf-stripping
2. Leaf-stripping at 50% silking

Data collection: Growth and yield (fodder and grain) of maize

Sub-activity RT2-Gh-1.8: Evaluating agronomic options to intensify groundnut production in northern Ghana

A recent expert consultation by the ICRISAT-led Groundnut Scaling project showed limited quantitative data on recommended phosphorus (P) fertilizer level and planting densities for groundnut varieties in northern Ghana. The objective of this joint Africa RISING and the Groundnut Scaling project activity is to identify appropriate P levels and planting densities to intensify production of released varieties of groundnut in northern Ghana. Two Experiments will be conducted.

In Experiment 1, five P levels (0, 30, 60, 90, 120 kg/ha P) effects on grain yield of eight groundnut varieties (Azivivi, Chinise, Obolo, Manipinta, Yenyenwoso, Samnut 22, Samnut 23 and Nkatie SARI) will be evaluated on-station across the 3 northern regions. The second experiment will evaluate the effect of various planting densities on grain yield of the released groundnut varieties.

The groundnut scaling project will provide Samnut 22 seed and technical backstopping on pest and disease management; whilst N2-Africa will be responsible for seeds of Samnut 23, P fertilizers, and technical backstopping on nitrogen fixation. Africa RISING will provide groundnut seeds (Azivivi, Chinese, Obolo, Manipinta and Yenyewoso) and technical backstopping on agronomic practices, and be responsible for the field establishment and monitoring of trial. Data to be collected include: grain and haulm yields.

Sub-activity RT2-Gh-1.9: Demonstration of Aflasafe product aflatoxin management in groundnut

This activity relates to Sub-activity RT5-Gh-3.5 and will be led by the IITA Aflasafe team. It will be jointly implemented by the Groundnut Scaling and Africa RISING projects. At a meeting held on 25 April with the Country Coordinator of the Groundnut project, it was agreed that this activity would be implemented in communities in 21 districts across the three northern regions where the Groundnut Scaling project is being implemented. Africa RISING (IITA) will provide the Aflasafe product, train farmers on the use of the product and collect samples from the demonstration plots for aflatoxin analysis. The Groundnut project will be responsible for the establishment and monitoring of the demonstration plots.

Sub-activity RT2-Gh-1.10: Organize a short-course on integrated crop-livestock production

Integrated crop-livestock systems predominate in the cereal-legume based farming systems in West Africa. Yet, most young researchers have limited skills in the design and implementation of integrated crop-livestock experiments. A short course will be organized for young scientists with background in the crop, livestock and biological sciences. Topics to be covered include integrated crop-livestock systems, design of integrated crop-livestock experiments, and analysis and presentation of data from integrated crop-livestock experiments.

Deliverables		Date (2016)
1	Revised database on completed IITA trials from 2013-2015	Aug
2	At least 3 mother trials established in 3-4 Technology Parks in the regions	Jul
3	At least 3 papers submitted for publication in impact-factored journals	Aug
4	At least 2 integrated crop-livestock trials established	Jul
5	A short course on integrated crop-livestock production organized	Aug
6	Graduate students (5MSc and 3 PhD) co-supervised	Oct
7	Joint trials established with SARD-SC, N2-Africa, Cowpea and Groundnut projects	Jul

Activity RT2-Gh-2	Test and disseminate improved crop varieties and agronomic practices	
Lead scientist(s)	Saaka Buah	SARI
Other scientist(s)	Roger Kanton, Peter Asongre, Julius Yilzagla, Francis Kusi, Mumuni Abudulai, Nicholas Denwar, James Kombiok, Issah Sugri, Kenneth Opere-Obuobi	
Location(s)	Selected intervention communities in the three regions	

Procedures

Sub-activity RT2-Gh-2.1: Establish database and publish results from completed studies on CKAN

Two years data collected from the following experiments will be used to develop a database. Data will be analyzed and results drafted for publication in peer reviewed journals by the responsible scientists.

1. Responses of extra-early, early- and medium-maturing maize varieties to N fertilizer in Northern, Upper West and Upper East regions (Buah, Kombiok, Kanton)
2. Responses of early- and medium-maturing soybean to P fertilizer and rhizobium inoculation in Upper West and Northern regions (Buah, Denwar)
3. Grain yield of dates of planting and spraying regime on grain and fodder yields of cowpea varieties (Abdulai, Kusi)
4. Integrated soil fertility management effects on grain and fodder yields and soil chemical and physical properties in soybean-maize rotations in Upper East Region (Kanton)
5. Integrated soil fertility management effects on grain and fodder yields and soil chemical and physical properties in cowpea-maize rotations in Upper West region (Buah)
6. Reducing post-harvest losses in cowpea and maize on-farm trials using 30-50 households per treatment in Northern and Upper East regions (Sugri, Abubakari)
7. Potential of round plastic containers to reduce post-harvest losses on-farm in Northern and Upper West regions (Sugri, Abubakari)
8. Sorghum hybrids yield potential in Northern, Upper West and Upper East regions (Opere-Obuobi, Buah, Kanton)
9. Evaluation and adaptation of millet varieties in Upper East Region using the Participatory Variety Selection method (Asongre)
10. Response of improved rice variety (Gbewaa) to different nitrogen levels in Upper East Region (Yirzagla)
11. Participatory evaluation of 8 varieties each of okra and roselle using IPM strategies in Upper East Region (Kusi)

Sub-activity RT2-Gh-2.2: Effect of variety and nitrogen fertilizer rates on rice

As with the 2015 cropping season, on-farm trials will be established in Bonia, Nyangua and Samboligo in Upper East Region to assess the agronomic and economic benefits of using varying rates of N fertilizer (0, 30, 60, 90 and 120 kg N/ha) on two rice varieties (Gbewaa and farmer variety) during the 2016 cropping season using the 'Mother' and 'Baby' trial approach. Interested households will be selected and given seed and fertilizer. Grain yield and farmer preference will be recorded.

Data collection: Tiller count 6 weeks after sowing, days to 50% flowering, plant height at maturity, days to maturity, panicle length, panicle weight, Thousand grain weight and grain yield

Sub-activity RT2-Gh-2.3: Early-maturing millet-cowpea strip cropping intensification among farmers in Upper East Region

Two improved varieties of cowpea and one of early-maturing millet will be used in a strip cropping experiment with the early rains. The cereal and legume will be sown in the following row combinations: 2 cereals:2 legumes; 3 cereals:3 legumes; 4 cereals:4 legumes. Participating farmers will be given inputs (seeds, fertilizer) and technical support to establish their plots. A basal dose of 100kg/ha NPK (15:15:15) will be given followed by a selective application of 20kg/ha N only on cereal rows and two sprays of insecticide only on the legumes. Randomized Complete Block Design with three or four replications, depending on land availability, will be used with plot size of 6m x 5m (30m²) and between rows spacing of 75cm. The intra-row spacing will be 20cm for both millet and cowpea. Three seeds of each crop will be sown and thinned to two plants per stand two weeks after sowing. At harvest, crop residues from half of the plot will be removed to feed the farmers' sheep and goats, while residues on the other half will be retained for soil fertility improvement. Both, biological (grain and fodder yield) and socio-economic (farmer preferred cowpea variety and strip cropping systems, labour input, gender distribution of chores) data will be collected.

Data collection: Plant establishment count per plot (millet and cowpea), plant height at maturity, plant count at harvest (millet and cowpea), days to 50% flowering (millet and cowpea), panicle length and panicle weight per plot (millet), pod weight per plot (cowpea), pod number per plant (cowpea) grain weight per plot (millet and cowpea), stover weight per plot (millet and cowpea), hundred seed weight, downy mildew infected plant count per plot (millet) and downy mildew incidence.

Sub-sub-activity RT2-Gh-2.4: Maize-soybean rotation

An on-station maize-soybean rotation trial to evaluate the response of soybean to organic, mineral and *Rhizobium* inoculants started in 2013 and will continue. Treatments are: 1) soybean (no soil amendment), 2) soybean + inoculant, 3) soybean + inoculant + 60kg/ha P₂O₅, 4) soybean + inoculant + fertiliser, 5) soybean + inoculant + fertiliser + 60kg/ha P₂O₅, 6) soybean + inoculant + 25-60-30kg/ha as N, P₂O₅, and K₂O continuous maize and 8) continuous soybean. The design is a randomized block with four replications. Plot size will be 4.5m x 5m (6-row plots). Soybean will be spaced 75cm x 5cm and maize at 75cm x 40cm. Data collection: Plant stand at 2 weeks after planting, days to 50% flowering (soybean), days to 50% silk and tassel emergence (maize); plant height, plant stand at harvest, number of cobs harvested (maize), cob weight (maize), grain yield and its components (maize and soybean), stover yield, number of kernel rows/cob, number of kernels/cob, Cob girth, cob length Soil analysis: N,P,K, pH, Soil organic carbon

Sub-sub-activity RT2-Gh-2:5 Maize-cowpea rotations

An on-station maize-cowpea rotation trial to evaluate the response of soybean to organic and mineral fertilizer and *Rhizobium* inoculant started in 2013 and will continue. Treatments are: 1) cowpea alone (no soil amendment), 2) cowpea + inoculant, 3) cowpea + inoculant + 60kg/ha P₂O₅, 4) cowpea + inoculant + fertiliser, 5) cowpea + inoculant + fertiliser + 60kg/ha P₂O₅/ha, 6) cowpea + inoculant + 25-60-30kg/ha as N, P₂O₅, and K₂O, 7) continuous maize and 8) continuous cowpea. The design will be a randomized block with four replications. Plot size will be 4.5m x 5m (6-row plots). Cowpea will be spaced 60cm x 10cm and maize at 75cm x 40cm. Plant height, days to flowering, pods per plant, grain and Stover yields, harvest index and soil chemical properties, pests and diseases will be monitored in all trials.

Data collection: Plant stand at 2 weeks after planting, days to 50% flowering (cowpea), days to 50% silk and tassel emergence (maize); plant height, plant stand at harvest, number of cobs harvested (maize), cob weight (maize), grain yield and its components (maize and cowpea)
Soil analysis: N,P,K, pH, soil organic carbon.

Deliverables		Date (2016)
1	At least 6-8 papers submitted for publication	Dec
2	Agronomic packages for cereal-legume production identified	Dec
1	Best agronomic practices and farmer preferred rice variety for rice production	Sep

Activity RT2-Gh-3 Intensification of rainfed and irrigated vegetable production systems

Lead scientist(s)	Jean-Baptiste Tignegre	Institution: AVRDC
Other scientist(s)	Richard Boateng, Alpha Sidy Traore, Larbi Asamoah, Abdul Nurudeen, Francis Kusi, Issah Sugri, Salim Lamini, Nana Yaw Obeng	
Student(s)	Theodore Eyram Avukpor, Mohammed Abdul Kadir, Jonathan Naaba, Iddrisu Bashiru	
Location(s)	Three selected communities in each region	

Procedures

Small-scale farmers produce vegetables under rain-fed conditions and under irrigation during the dry season. In both systems, yields are low due to the use of unimproved varieties, poor agronomic and water management practices, and lack of good access to information.

Since AVRDC does not have a presence in Ghana, it will leave 50% of budget allocation with IITA to hire research assistants who will assist with the implementation of AVRDC's research activities. AVRDC will be responsible for the implementation of the trials. IITA will provide administrative support for the staff.

Sub-activity RT2-Gh-3.1: Improving productivity of rain-fed vegetable cropping systems

The objective of this activity is to locally increase access to quality seeds of indigenous vegetables during the rainy season. The six vegetable hubs in Upper East Region (lead farmers) will produce seeds to face the demand by farmers. Okra, pepper and roselle are the target crops. Each of the six lead farmers will implement 1000m² to 1500m² of one of the three species.

Data collection: Quantity of seeds produced, seed quality traits (germination rate, percentage off-types roughed, diseases scores, average annual rainfall, number of farmers attending training on seed production techniques.

Sub-activity RT2-Gh-3.2: Improving productivity of dry season vegetable cropping systems

The objective of this activity is to evaluate a combination of agronomic practices on productivity of vegetable production during the dry season. The trials on pure stands of vegetables will be conducted with lead farmers in the six vegetable hubs in Upper East Region, as well as in 30 non-lead farmers' fields in Tekuru and Nyangua. Training session will be organized on vegetable production techniques for farmers. This activity will be led by AVRDC in collaboration with IWMI.

- (i) Irrigation option (drip water and water can irrigation)
- (ii) 2 Fertilizer dose response (manure, no manure)
- (iii) 2 IPM options (neem oil, recommended pesticide)

Data collection: Days to 50% flowering and maturing, plant height, fruit number, fruit size of five randomly selected plants or fruits, fresh fruit weight (1st, 2nd and 3rd harvest), daily temperatures and humidity during cropping season.

Sub-activity RT2-Gh-3.3: Data analysis

Data from the 2013/14 and 2014/15 research years will be analyzed. Results will be used to draft a paper for publication in peer reviewed journals.

Deliverables		Date (2016)
1	Establish at least 3 vegetable experiments in the Upper East Region	Jun
2	At least 200 farmers of Upper East, Upper West and Northern regions exposed to vegetable production, protection, irrigation, post-harvest managements and seed production techniques	May
3	Seed of farmer preferred vegetable varieties produced	Oct
4	Article on maize-vegetable intercropping published in scientific journal	Sep

Expected outcomes

1. More households are integrating vegetables in their cropping system
- 2.-Farmers are adopting improved agronomic practices
3. More farmers are integrating livestock into their cropping systems

5. Budget (US\$x1000)

Theme/Activity	Budget Line	IITA	AVRDC ¹	SARI	MoFA ²	UDS ²	AGRIMAT ²	KNUST ²
RT2-Gh-1	Personnel	125						
	Services	50			2			
	Supplies	50			3			
	Travel	25			10			
RT2-Gh-2	Personnel			24				
	Services			12				
	Supplies			8				
	Travel			6				
RT2-Gh-3	Personnel		30					5
	Services		20			5		5
	Supplies		19			3	5	2
	Travel		15			2		3
	Total	250	84	50	15	10	5	15
Grand total		429						

¹US\$ 40,000 of the budget allocation to AVRDC is to be retained by IITA for salary and operational cost of an AVRDC research assistant based in the Upper East

²Budget allocations to MoFA, UDS, AGRIMAT and KNUST to be retained by IITA and paid to the partners and graduate students directly upon implementation of activities.

Theme 3: Intensive livestock production (RT3-Gh)

1. Research team

<i>Name</i>	<i>Institution</i>	<i>Degree</i>	<i>Research interest</i>	<i>Role</i>
Augustine Ayantunde	ILRI	PhD	Feeds, animal husbandry	Leader, RT3-Gh-1
Tunde Amole	ILRI	PhD	Feeds, animal husbandry	RT3-Gh-1
Franklin Avornyo	ARI	PhD	Feeds, animal husbandry	RT3-Gh-1
Asamoah Larbi	IITA	PhD	Crop-livestock production	Leader, RT3-Gh-2
Emmanuel Panyan	ARI	PhD	Forage agronomy	RT3-Gh-1
Michael Boateng	KNUST	PhD	Monogastric nutrition	RT3-Gh-2
Sadat Salifu	ARI	MSc	Reproductive physiology	RT3-Gh-1
Addah Weseh	UDS	PhD	Feeds, animal husbandry	RT3-Gh-1
Henry Alagma	UDS	BSc	Ruminant nutrition	MSc student
Herbert Dei	UDS	PhD	Poultry nutrition	RT3-Gh-2
Ben Alenyorege	UDS	MSc	Pig nutrition	RT3-Gh-2
Mary Awuni	UDS	BSc	Monogastric nutrition	MSc student
Daniel Apalibe	UDS	BSc	Monogastric nutrition	MSc student
Goodman Safo	KNUST	MSc	Monogastric nutrition	PhD student
Amponsah Bright	KNUST	BSc	Pig production	MSc student
Raphael Ayizanga	KNUST	MSc	Animal breeding	PhD student
Solomon Konlan	UDS	MSc	Nutrient cycling	PhD student

2. Objectives

- 1 Test feed/health options to improve productivity and nutrient cycling in sheep/goat production
- 2 Evaluate options to increase productivity of rural poultry production
- 3 Evaluate options to improve productivity of rural pig production
- 4 Test and disseminate options to increase crop and livestock outputs from fallow lands
- 5 Test and disseminate agronomic strategies to optimize feed supply from cereal-legume cropping systems
- 6 Identify high-yield and better quality cereal and legume crop genotypes for food and feed
- 7 Improve capacity of extension staff, researchers and farmers in integrated-livestock production

3. Activities

Deliverables	Date (2016)
1 Report and a draft manuscript on improved small ruminant production	Dec
2 Manual on improved small ruminant production for smallholder farmers and extension workers	Sept
3 Report on conservation of crop residues for improved small ruminant productivity	Sept

4	Database on nutritional quality of feed resources in Northern Region	Jun
5	Report on fodder production	Dec

Activity RT3-Gh-2 Evaluate and disseminate options to intensify rural poultry and pig production

Lead scientist(s)	Michael Boateng	Institution: KNUST
Other scientist(s)	Asamoah Larbi, Herbert Dei, Ben Alenyorege	
Student(s)	Goodman Safo-Kantaka, Daniel Apalibe, Raphael Ayizanga	
Location(s)	Tibali, Duko, Botingli, Tibognayili, Cheyohi (Northern Region), Samboligo, Bonia, Nyangua(Upper East Region), Zanko, Guo, Passe, Goli, Natorduori (Upper West Region)	

Procedures

Sub-activity RT3-Gh-2.1: Organize expert consultation on livestock research

Livestock related activities in the project have been implemented under the leadership of ILRI (sheep and goats), UDS (poultry) and KNUST (pigs) over the past four years. The IITA (2014) and USAID (2015) commissioned evaluation teams recommended involvement of additional public and private sector partners to make the livestock component (especially activities related to sheep and goat, pig and poultry production) more visible. The Animal Production Division and the Veterinary Services Division of MoFA and private sector actors have played limited roles in the implementation of the livestock activities.

The objective of this activity is to organize a 2-day meeting of the relevant partners to identify researchable livestock activities for joint implementation if there should be a Phase 2.

Sub-activity RT3-Gh-2.2: Develop, evaluate and disseminate improved technologies to intensify poultry production

The survey in 2013 identified lack of enabling institutions and policies, poor market access, lack of improved breeding, inappropriate husbandry (housing, feeding, breeding and health care) practices, as well as lack of information/knowledge as key constraints to rural poultry production. In 2016, farmer participatory research to test a combination of housing, feeding and health packages to address the constraints will be continued. The exact packages to be tested will be determined from consultations with farmers and the R4D Platforms. Most likely, combinations will be to test the traditional systems of management (control) and improved management (housing, health-care and feeding) using a randomized complete block design with districts as blocks.

Trials will be conducted on both domestic chicken and guinea fowls.

Data collection: Matured live-weight, duration to maturity, mortality, duration of brooding, number of eggs, production costs, income, quantity of manure and profit over a period of 40 days.

Sub-activity RT3-Gh-2.3: Develop, evaluate and disseminate technologies to intensify rural pig production

In 2016, farmer participatory approaches will be used to develop, evaluate and disseminate a combination of housing, feeding, breeding and health care options to improve and intensify rural pig production. The exact packages to be tested will be determined from consultations with farmers and the R4D Platforms. These may likely include trials on comparison of extensive versus intensive management; effect of supplementation in performance of grower and finisher pigs under the free range management system; a survey to document green forage species fed to pigs, and the performance of growing pigs supplemented with different levels of concentrates; development and testing of breeding strategies to reduce inbreeding, meat processing and linking farmers to markets.

Data collection: Feed intake, body weight gain, feed conversion efficiency, mature live-weight, mortality rate, production costs and net profit will be recorded. The impact of the improved technologies on household income will be assessed.

Deliverables		Date (2016)		
1	Two MSc students defend their dissertation at KNUST		May	
2	Booklet on challenges and opportunities for improved rural poultry production		Sep	
3	At least 2 papers submitted for publication in peer reviewed journals		Jun	
4. Expected outcomes		Short	Medium	Long
1	More households keep their livestock under intensive management	x	x	x
2	Households have improved manure management		x	x
3	Farmers are adopting lamb fattening to capture niche markets		x	x
4	Village committees are managing fallow lands		x	x
5	Households are producing more feed from cropping systems	x	x	
6	National researchers are implementing more integrated crop-livestock activities	x	x	x

5. Budget (US\$x1000)

Theme/Activity	Budget Line	IITA	ILRI	UDS ¹	KNUST ¹	MoFA ¹
RT3-Gh-1	Personnel		72			
	Services		36			
	Supplies		44			
	Travel		18			
RT3-Gh-2	Personnel	5		9	10	7
	Services	6		6	7	5
	Supplies	12		5	5	5
	Travel	4		3	3	3
	Total	27	170	23	25	20
	Grand total	265				

¹Budget allocations to MoFA, UDS and KNUST to be retained by IITA and paid to the partners and graduate students directly upon implementation of activities.

Theme 4: Land, soil and water management (RT4-Gh)

1. Research team

<i>Name</i>	<i>Institution</i>	<i>Degree</i>	<i>Research interest</i>	<i>Role</i>
Davie Kadyampakeni	IWMI	PhD	Soil and water	Leader, RT4-Gh-1,2
Fred Kizito	CIAT	PhD	Soil and water	Leader, RT4-Gh-3,4
Eliasu Salifu	CIAT	MSc	Soil and water	Agronomy
Jean-Baptiste Tignegre	AVRDC	PhD	Vegetables	Horticulture
Kennedy Nganga	CIAT	BSc	GIS/Remote sensing	Field mapping
Pamela Katic	IWMI	PhD	Economics	Market links
Everisto Mapedza	IWMI	PhD	Soil science	Gender analysis
Wilson Agyare	KNUST	PhD	Soil, crops, agronomy	Trials on RT4-Gh-1-4
Francis Tetteh	SRI	PhD	Soil, crops, agronomy	Soil science
Emmanuel Panyan	ARI	PhD	Soil, crops, agronomy	Agronomic expertise
Rockefeller Achuliwor	KNUST	BSc	Soil and Water	Graduate Student
Nana Yaw Obeng	AGRIMAT	MSc	Post-Harvest/Water	RT4-Gh-1

2. Objectives

The main objective in this work-package is to improve soil, land and water management practices to improve crop-livestock production systems of northern Ghana. Specifically, this component will:

- 1 Test small-scale irrigation technologies for dry season vegetable production
- 2 Test water management practices to improve productivity in rained crop-livestock systems
- 3 Prepare and disseminate knowledge materials to end users
- 4 Evaluate options to improve land and soil management practices within farming systems
- 5 Draft and submit 2-3 journal papers
- 6 Monitor, implement and demonstrate best-bet on-farm water, soil and land conservation interventions for improved water, soil and nutrient retention
- 7 Provide farmer recommendations and conduct trade-off analysis coupled with scenario generation for soil and land restoration strategies that highlight associated economics of land degradation and restoration management

3. Activities

Activity RT4-Gh-1	Testing small-scale irrigation options for dry season vegetable ¹ production	
Lead scientist(s)	Davie Kadyampakeni	Institution: IWMI
Other scientist(s)	Pamela Katic, Everisto Mapedza, Jean-Baptiste Tignegre, Fred Kizito, Wilson Agyre, Nana Yaw Obeng	
Location(s)	Tekuru, Nyangua in the Upper East Region	

Procedures

Irrigation management is critical for sustainable crop production, particularly in the dry season. The following sub-activities will be implemented and linked to the ILSSI project in one of the selected sites.

Sub-activity RT4-Gh-1.1: Quantifying of surface and groundwater resources

Quantifying of surface and groundwater resources will be conducted for watersheds where AR target communities are located in order to assess feasibility of dry season vegetable production and supplementary irrigation of cereal-legume rainfed crops.

Data collection: Rainfall and runoff data, stream flows, estimated storage volumes of wells and reservoirs, well recharge rates over time.

Sub-activity RT4-Gh-1.2: Participatory evaluation of water lifting and water delivery methods for vegetable production

Various water lifting and conveyance technologies will be compared with regards to water productivity, labor and cost requirements for the dry season vegetable production. An understanding of how men and women have differential access and control over the different technological options will be determined.

The following water lifting and delivery technologies will be implemented:

- Water lifting technologies: i) motorized pump, ii) solar pump and iii) water cans/buckets
- Water application methods: i) drip, ii) furrow, iii) overhead tank with a hose, iv) bucket irrigation and v) sprinkler irrigation

Data collection: Water volumes lifted and applied, number of irrigation times per season, crop yields (biomass and fruit), soil chemical and physical parameters, labor (man-days), labor roles for men and women, time spent on irrigation and other agricultural practices, fuel expenses on pumps, costs of pumps, inputs and labor.

¹The vegetables will be selected in consultation with farmers, IITA, AVRDC and NGOs working in the area.

Sub-activity RT4-Gh-1.3: Assessment of irrigation frequency and amount using different irrigation scheduling methods

A simple tool (sensor-based) will be tested to assist farmers in the irrigation scheduling of vegetables. The tool indicates when the root-zone is dry and when it becomes saturated during irrigation. The water productivity and overall irrigation application rates using the sensors will be compared against i) a fixed irrigation schedule and ii) the farmers' normal practice. The assessment on farmers' fields will include appropriate nutrient and pest management practices and it will provide an opportunity for farmers to compare the tested irrigation scheduling methods with respect to water, labor and time savings. This will also provide the framework for farmers to judiciously optimize irrigation management in water scarce environments.

Data collection: Water volumes applied, number of irrigation times per season, crop yields (biomass and fruit), soil chemical and physical parameters, labor (man-days), labor roles for men and women, time spent on irrigation and other agricultural practices, fuel expenses on pumps, costs of pumps, inputs and labor.

Deliverables		Date (2016)
1	Journal manuscript on watershed characterization drafted and submitted	Aug
2	Conduct farmer exchange visit on improved watershed management and irrigation systems	May
3	Upload collected watershed characterization and irrigation data on CKAN	Oct , Feb 2017
4	Report on gender aspects of water lifting technologies	Nov

Activity RT4-Gh-2	Exploring potential supplementary irrigation in rainfed crop-livestock production system	
Lead scientist(s)	Davie Kadyampakeni	Institution: IWMI
Other scientist(s)	Pamela Katic, Asamoah Larbi, Emmanuel Panyan, Fred Kizito, Wilson Agyare	
Location(s)	Nyangua, Upper East Region	

Procedures

The rain-fed crop-livestock production system requires demonstration of effective water management interventions to enhance productivity. In particular, crop production is often affected by rainfall irregularities and is actually scarce during the dry season. This activity component will explore with farmers, the potential for adopting irrigated dual purpose crop production in Ghana. The following sub-activities will be implemented.

Sub-activity RT4-Gh-2.1: Dry spell analysis of selected catchments in Northern and Upper East regions This sub-activity will include the analysis of long-term rainfall trends on data collected for the past 30 to 50 years in cereal (maize, sorghum and millet) and legume (cowpea, soy bean) cropping system. The dry spell analyses, a follow-up to biophysical watershed characterization done in 2015/2016 will be supported with simulations of cropping scenarios under supplementary irrigated or entirely rainfed conditions to provide guidelines for supplementary irrigation.

Data collection: Rainfall data for selected Africa RISING catchments, dry spell analyses' graphs for maize, sorghum, millet, cowpea and soybean, simulated data using APSIM or DSSAT cropping systems models for one cereal and one legume with supplementary irrigation and rainfall.

Sub-activity RT4-Gh-2.2: Piloting supplementary irrigation for dual purpose crop production

Under supplementary irrigation dual purpose crops will be produced, specifically maize and cowpea, soybean or groundnut.

Data collection: Crop grain and biomass yield under supplementary irrigation and rainfall, rainfall data, irrigation amount and number of irrigations.

Deliverables		Date
1	Deploying of dual purpose production plots and farmer training in Upper East Region	(2016) Aug
2	Journal manuscript on dry spell analysis for informed decision making on cultural practices and supplementary irrigation options	Oct
3	Data on crop yield biomass, water use and water applied uploaded to CKAN	Oct
4	Technical report and guidelines on irrigated dual purpose production drafted	Dec
		Feb (2017)

Activity RT4-Gh-3	Piloting improved combinations of soil and land management strategies on-farm	
Lead scientist(s)	Fred Kizito	Institution: CIAT
Other scientist(s)	Davie Kadyampakeni, Wilson Agyare, Francis Tetteh, Kennedy Nagger	
Location (s)	Bonia, Nyangua and Gia (Upper East Region), Northern Region	

Procedures

In order to provide viable interventions and recommendations, we propose piloting of on-farm trials to address erosion prevalence and land degradation that will in turn increase crop productivity through three sub-activities outlined below:

Sub-activity RT4-Gh-3.1: Re-inforce and maintain established on-farm land and soil conservation structures

This will entail maintenance of established tied-ridges, cover crops, and contour cropping compared against farmer practices.

Sub-activity RT4-Gh-3.2: Monitor soil losses, nutrient movements and soil moisture variation

To provide evidence for sub-activity 1.1:

- Soil losses will be monitored by a modified version of runoff soil loss detectors that captures 75% of the plot runoff zone; the dimensions of the runoff detectors are 1m x 0.15m x 0.15m.
- Nutrient dynamics will be monitored using suction lysimeters which will be held at a tension of 70cbar and installed at varying depths along the profiles of interest in order to ascertain fate and transport as well as verify what percentage is captured within the crop root zone;
- Soil moisture will provide vital links to both soil and nutrient losses. Soil moisture will be monitored using a diviner probe (Sentek Inc.) to depths of 1m at 10cm increments within the profile. Access tubes for moisture measurement with the diviner probe will be installed in the center position of the target plots.

Sub-activity RT4-Gh-3.3: Evaluate effectiveness of land and soil conservation structures towards mitigating soil losses, nutrient losses and soil moisture conservation

This will entail conducting a detailed analysis of the spatial and temporal trends of the data collected through monitoring in sub-activity 3.2. Essentially, the assessment will include evaluation of soil conservation practices (both structural and vegetative) towards environmental integrity (allowing moisture infiltration, reducing erosion and nutrient losses).

Data collection: Weather data (rainfall, relative humidity, air temperature, solar radiation); soil moisture variation per treatment on a weekly basis; this is complemented by automated data measured every 15 minutes for some treatments; runoff and soil losses with calibrated soil traps, soil nutrient dynamics with a suction lysimeter; infiltration rates with a mini-disk infiltrometer.

Deliverables	Date (2016)
1 Planning with partners, field layouts implemented and instrumentation deployed; On-farm land and soil conservation structures reinforced and maintained	Aug
2 Technical Report on effectiveness of land and soil conservation structures towards mitigating soil losses, nutrient losses and soil moisture conservation	Oct
3 Soil losses, nutrient dynamics and moisture variation data uploaded on CKAN	Oct
4 Regional online climatic data analysis from on-farm weather stations in Upper East, Northern and Upper West regions rolled out and availed to partners and other AR Themes for decision making	Nov

Activity RT4-Gh-4	Farmer recommendations, tradeoff analysis and scenario generation for land restoration strategies	
Lead scientist(s)	Fred Kizito	Institution: CIAT
Other scientist(s)	Wilson Agyare, Francis Tetteh, Kennedy Nganga	
Location (s)	Bonia, Nyangua and Gia (Upper East Region), Northern Region	

Procedures

Sub-activity RT4-Gh-4.1: Economics of farm productivity in the context of soil conservation measures

This will involve: conducting economics of farm productivity that incorporate labor and level of effort for land and soil conservation measures; quantifying losses associated for the lack of action (would use on-farm counter-factual results); and quantify (monetary and non-monetary) the benefits of action associated with interventions. Collecting data on farmers' allocation of time to daily farming activities will be linked to mapping of farmers' lands including details of farming practices and land use that was conducted in an earlier study over the same sites.

Sub-activity RT4-Gh-4.2: Policy and farmer recommendations, tradeoff analysis and scenario generation

This consists of: simple farmer-tailored recommendations that communicate key recommendations; a web-based interface for the research community, policy makers and implementing NGOs on key findings; and overall synthesis for trade-off matrix and scenario generation based on above sub-bullets.

A key component of this sub-activity will include an exchange learning field visit of lead farmers in both the Northern Region and Upper East Region to demonstration farms on soil and water conservation in another region of Ghana at the Center for No-Till Agriculture.

Sub-activities RT4-Gh-4.1 and 4.2 will document the biophysical (soil properties and crop yield) and socioeconomic (income and other quality of life indicators) benefits that farmers achieve through soil and water conservation practices. The findings will provide insight on policies that will further encourage farmer adoption of soil and water conservation practices that can then be further passed on to the Ghanaian government.

Data collection: Labor (man-hours, man-days) and level of effort for land and soil conservation measures; quantify (monetary and non-monetary) the benefits of action associated with interventions, soil properties (texture, structure), crop yields and socioeconomic variables such as acceptability of intervention and other quality of life indicators (education and information empowerment).

Deliverables

		Date (2016)
1	Training of lead farmers and agricultural extension agents conducted with an exchange field visit for soil and water conservation	May
2	Farmer recommendations for soil and water conservation drafted	Sep
3	Journal manuscript on tradeoff analysis and scenario generation completed	Aug

4. Expected outcomes

		Short	Medium	Long
1	Households are adopting improved water, soil and land management		x	x
2	More households are harvesting water for dry season vegetable production	x	x	x
3	Improved water management and water savings in dry season vegetable irrigation in smallholder production systems		x	x
5	Increased acreage of farm lands under improved soil and water conservation practices		x	x

5. Budget (US\$x1000)

Theme/Activity		IWMI	CIAT ¹	KNUST ²
RT4-Gh-1	Personnel	25		
	Services	10		3
	Supplies	10		5
	Travel	5		2
RT4-Gh-2	Personnel	25		
	Services	10		
	Supplies	10		
	Travel	5		
RT4-Gh-3	Personnel		25	
	Services		10	
	Supplies		10	
	Travel		5	
RT4-Gh-4	Personnel		25	
	Services		10	
	Supplies		10	
	Travel		5	
	Total	100	100	10
Grand total		210		

¹US\$ 40,000 of the budget allocation to CIAT is to be retained by IITA for salary and operational cost of an CIAT research assistant based in the Upper East

²Budget allocations to KNUST to be retained by IITA and paid to the partner and graduate students directly upon implementation of activities.

Theme 5: Nutrition, food storage, value addition and mycotoxin management (RT5-Gh)

1. Research team

<i>Name</i>	<i>Institution</i>	<i>Degree</i>	<i>Research interest</i>	<i>Role</i>
Mahama Saaka	UDS	PhD	Public health nutrition	Leader, RT5-Gh-1
Sofo Mutaru	GHS	MSc	Community nutrition	RT5-Gh-1
Jacob Mahama	GHS	MPh	Public nutrition	RT5-Gh-1
Bridget Parwar	WIAD	MSc	Community nutrition	RT5-Gh-1
Chrisantus Daari	GHS	MSc	Community nutrition	RT5-Gh-1
Gloria Kobati	GHS	MSc	Community nutrition	RT5-Gh-1
Mary Paula Kogana	WIAD	MSc	Community nutrition	RT5-Gh-1
To be identified		PhD	Postharvest management	Leader, RT5-Gh-2
Asamoah Larbi	IITA	PhD	Crop-livestock systems	RT5-Gh-2, Coordination
Bekele Kotu	IITA	PhD	Agric. Economics	RT5-Gh-2
Issah Suguri	SARI	MSc	Post-harvest management	RT5-Gh-2
Nana Yaw Obeng	AGRIMAT	MSc	Post-harvest management	Consultant
Matilda Steiner-Asiedu	UG	PhD	Nutrition	Nutrition strategy
Daniel Obeng-Ofori	UNR	PhD	Entomology	Consultant RT5-Gh-1
Ranjit Bandyopadhyay	IITA	PhD	Mycotoxin management	Guidance
Abuelgasim Elzein	IITA	PhD	Mycotoxin management	Leader, RT5-Gh-4
Alejandro Ortega-Beltran	IITA	PhD	Mycotoxin management	Co-leader, RT5-Gh-4
George Opit	PHL-IL	PhD	Pest management	PHL-ILs contact
Francis Appiah	KNUST	PhD	Food technology	Leader, RT5-Gh-3
Daniel Agbetiamah	KNUST	MSC	Mycotoxin management	PhD student
Richard Awuah	KNUST	PhD	Mycotoxin management	RT5-Gh-4

2. Objectives

- 1 Compare the nutritional and health outcomes of focused behavior change communication (BCC) combined with nutrition-sensitive agriculture interventions with only agricultural interventions among children and pregnant mothers
- 2 Establish a linkage between aflatoxin biocontrol using Aflasafe, nutrition, post-harvest and livestock teams to harmonize awareness creation campaigns to improve knowledge on better household nutrition, improved crop storage practices, and the menace of aflatoxin to human health, animal productivity and trade.
- 3 Improve mothers' knowledge in nutrition, hygiene and feeding practices
- 4 Determine the nutritional and anti-nutritional characteristics of cereal and legume-based food products as consumed in the target communities
- 5 Introduce and test the acceptability of nutritionally enhanced crops and vegetables
- 6 Conduct studies on effect of traditional processing methods on nutrient retention and bioavailability

- 7 Introduce, evaluate and promote technologies to reduce post-harvest losses in stored cereal and legume grains at the household and community levels
- 8 Introduce, evaluate and promote labor saving devices for value additions/processing
- 9 Test the efficacy of bio pesticides Aflasafe GH01 and Aflasafe GH02 to reduce aflatoxin levels under farm conditions and initiate pilot-scale scaling up of the bio pesticides
- 10 Conduct training of trainers workshops on improved soybean and cowpea processing, product development and food hygiene/safety
- 11 Build individual (MSc and PhD) and institutional capacity for research on post-harvest losses and value addition

3. Activities

Activity RT5-Gh-1	Improve household nutrition	
Lead scientist(s)	Mahama Saaka	Institution: UDS
Other scientist(s)	Chrisantus Daari, Gloria Kobati, Sofo Mutaru, Bridget Parwar, Mary Paula Kogana	
Consultant	To be identified	
Location(s)	Intervention communities in the three regions	

Procedures

Sub-activity RT5-Gh-1: Develop a nutrition strategy

In response to the recommendations of the USAID commissioned evaluation team, a consultant will be hired to develop a nutrition strategy for the regional project. The strategy will indicate how the nutrition activities will be linked to the livestock and crop research activities (See Sub-activity RT1-Gh-5.1).

Sub-activity RT5-Gh-1.2: Improve mothers' knowledge in nutrition, hygiene and feeding practices
BCC sessions will be held at the community level to improve nutrition and hygiene practices. Cooking demonstration sessions at the community level will be organized to train women on the preparation of appropriate recipes using locally available food types.

Formation/re-activation of mother to mother support groups which should meet monthly in each community to share key messages including the importance of diversifying diets, nutrition during pregnancy, early and exclusive breastfeeding, the appropriate quantity and quality of complementary foods, and preventive healthcare services, such as immunizations, and antenatal care.

Data collection: Changes in nutritional knowledge of women, information on behavior change communication messages and delivery mechanisms (e.g. positive deviance approaches), information on the formation and functioning of local/village mother-to-mother support group (MTMSG), data on personalized counseling and negotiated behavioral change actions given to parents about caring practices to improve child growth.

Sub-activity RT5-Gh-1.3: Evaluate strategies for improving household nutrition

Establish links with crops, water management and livestock components of the project for the production of nutritious foods for households. End-line evaluation of ongoing community intervention will be carried out in 50 intervention and comparison communities. The assessment will compare the impact of providing BCC messages to individual mothers via peer counselors and providing such messages through Positive Deviance (PD) approach.

The interventions that are being implemented are:

- Legumes, Vegetables and Livestock + BCC delivered through community GMP
- Legumes, Vegetables and Livestock + BCC delivered through Positive Deviance (PD) approach.

The comparison communities have received no interventions from IITA.

Data collection: WHO Infant and young child feeding (IYCF) practices to measure minimum dietary diversity (MDD), minimum meal frequency (MMF), minimum acceptable diet (MAD), nutritional status of children measured in terms of height-for-age Z-score (HAZ), weight-for-height Z-score (WHZ) and weight-for-age Z-score (WAZ), Body mass index (BMI) and mid upper arm circumference for women, food access information as measured by household food insecurity access scale (HFIAS), changes in nutritional knowledge of women.

Deliverables		Date (2016)
1	800 women trained in positive deviance approach to nutrition delivery	Oct
2	End-line evaluation report on strategies to improve household nutrition	Feb (2017)

Activity RT5-Gh-2	Reducing postharvest losses in stored grains of cereals and legumes	
Lead scientist(s)	Asamoah Larbi and Consultant	Institution: IITA
Other scientist(s)	Issa Sugri, George Opit, Bekele Kotu, Daniel Obeng-Ofori	
Consultant(s)	To be identified	
Student(s)	To be identified	
Location(s)	Tibali, Duko, Tibognayili, Cheyohi (Northern Region), Samboligo, Bonia, Nyangua (Upper East Region), Zanko, Guo, Passe, Goli, Natorduori (Upper West Region)	

Procedures

On-farm trials will be conducted to evaluate, adapt and disseminate storage technologies to reduce post-harvest losses in stored grain, especially maize, groundnut and cowpea.

The activities will be undertaken in collaboration with AGRIMAT and consultants from the private and public sectors.

Most of the on-farm studies will use a randomized complete block design (RCBD) with communities as blocks and households as replicates, and farmers' current practices as controls. The trials will be conducted in 6 communities with 10-20 households per treatment based on the size of the community. The trials will be conducted over 12-18 months. Data to be collected every two months will include: pest infestation, volume per weight loss, quality losses (physical, biochemical, nutritional, economic), aflatoxin levels and farmers' perceptions.

Sub-activity RT5-Gh-2.1: Evaluate and demonstrate small-scale machinery and post-harvest products

This activity will be implemented with public and private sector partners to evaluate and demonstrate some of their products. Small-scale, labor-saving machinery (shellers, planters, tillers, fodder choppers) and post-harvest products (e.g., Super Grain Bags, Collapsible Dryer Case and Sil bags) will be evaluated against farmers' current practice in the Africa RISING intervention communities in the three regions. Male and female farmers' preferences, labor and time saved by the introduced machinery will be recorded. Cost-benefit ratio of using the machinery will be determined.

Sub-activity RT5-Gh-2.2: On-farm comparison of storage technologies to prevent stored-product insect infestation of maize

Treatments will include:

1. Actellic Super-treated maize in 50kg polyethylene bags (poly sacks)
2. Untreated maize in 50kg polypropylene (PP) bags
3. Untreated maize in 50kg deltamethrin (DM) incorporated polypropylene VF ZeroFly bags
4. Untreated maize in 50kg Super Grain Bags (GrainPro)
5. Untreated maize in 50kg PICS bags

Deliverables

	Date (2016)
1 A post-harvest research team is established	Jun
2 Appropriate post-harvest technologies for testing and scaling identified	Jul
3 Communities are identified for implementation of post-harvest activities	Aug
4 Post-harvest trails and demonstrations initiated in at least 4 communities	Oct

Activity RT5-Gh-3 Biological control of aflatoxins in maize and groundnut with Aflasafe GH01

Lead scientist(s)	Ranajit Bandyopadhyay	Institution: IITA
Other scientist(s)	Abuelgasim Elzein, Alejandro Ortega-Beltran	
Consultant	Richard Awuah	
Student(s)	Daniel Agbetiamah	
Location(s)	Tibali, Duko, Tibognayili, Cheyohi, (Northern Region), Nyangua, (Upper East Region), Zanko, Guo, Passe, Goli, Natorduori (Upper West Region)	

Procedures

Sub-activity RT5-Gh-3.1: Intensive laboratory analyses of nearly 1,000 samples collected from the comprehensive field efficacy evaluation trials of Aflasafe GH01 and Aflasafe GH02, conducted across different environments in Ghana in 2015

Carry out microbiology analysis (strain isolation, mutant development, and complementation) in IITA-Ibadan of the collected soil samples from both treated and control fields before Aflasafe application and three months after harvest, to determine the native population structure of *Aspergillus* in these fields and carryover potential of the atoxigenic strains constituting the two Aflasafe products.

Carry out microbiology (strain isolation, mutant development, complementation) and chemical (aflatoxin extraction and quantification) analyses in IITA-Ibadan to generate efficacy data for the collected grains samples from both treated and control fields after application, for evaluating field efficacy and recovery atoxigenic strain constituents of the applied products (Aflasafe GH01 & Aflasafe GH02).

Data collection: Densities of *Aspergillus* species and frequencies of the strains composing both Aflasafe products will be determined in soils of treated and control fields before harvest and three months after harvest. Densities of *Aspergillus* species and frequencies of the strains composing both Aflasafe products will be determined in crops at the time of harvest. In

addition, aflatoxins will be quantified in treated and control fields to determine efficacy of both Aflasafe products in reducing aflatoxin accumulation. These set of efficacy data are a prerequisite for the preparation of a registration dossier and will provide proof and evidence to facilitate registration of the products and future commercialization.

Sub-activity RT5-Gh-3.2: Sensitization and training workshops

The scope of public sensitization on aflatoxin and its management through novel biocontrol technology will be continued and broadened. For increasing awareness and enhancing participation on aflatoxin biocontrol activities, selected health personnel from the Ghana Health Service and Agricultural Extension Agents (AEAs) will be trained on the health impacts of consuming aflatoxin contaminated food. Further, AEAs and lead farmers in focused communities will be trained on aflatoxin biocontrol using Aflasafe, its mode of application, crop and soil sampling techniques. These trainers (health personnel, AEAs and lead farmers) will in turn sensitize and train households in their focused communities. Target category of household participants will include farmers, aggregators, millers, poultry farmers, and traders.

Data collection: Age, sex, cropping system, and farm size of farmers attending the sensitization and training workshops.

Stakeholder trainings and sensitizations will be frequently monitored to ensure effective delivery. The planned awareness and training activities of this work package will be linked to those led by the other activities under this research theme.

We will also try to coordinate and link this activity with ICRISAT work on aflatoxin management in groundnut in Africa RISING project.

Sub-activity RT5-Gh-3.3: Large-scale field efficacy validation trials for pre-registration of Aflasafe GH01 and Aflasafe GH02 as bio pesticides

Following the sensitization and training workshops, farmers and/or farmer associations and sites for on-farm efficacy evaluation of the Aflasafe biocontrol agents will be identified and selected from the Africa RISING focus communities. A total of 240 fields will be selected, comprising 60 each treated and untreated (control) maize fields (i.e. 20 fields per region) and 60 treated and untreated (control) groundnut fields (i.e. 20 fields per region). Field sizes will range between 0.3ha and 1ha and separated from control fields by at least 25m. Each field will be considered a replicate.

Three tons of quality Aflasafe products (one and half ton each of Aflasafe GH01 and Aflasafe GH02) will be produced by IITA Aflasafe Manufacturing Plant, in Ibadan, Nigeria, for these large-scale field efficacy validation trials in northern Ghana.

The trials will be conducted on crops grown by farmers as per their normal agronomic practices. Farmers will be sensitized and trained on application time and method of the Aflasafe biocontrol products.

Field soil samples will be collected prior to application of the Aflasafe biocontrol products to measure the native population structure of *A. flavus* and after harvesting to measure the changes in the *Aspergillus* community structure due to biocontrol product application. During the 2016/17 project year (from Oct 2016 onwards), sample collection of maize and groundnut

grains and soil after application will be carried out for microbial and chemical (aflatoxin) analyses to generate efficacy data. Large data sets will be generated from the extensive analyses of samples collected from the planned comprehensive field efficacy evaluation trials of Aflasafe GH01 and Aflasafe GH02.

Data collection: Densities of *Aspergillus* species and frequencies of the strains composing both Aflasafe products will be determined in soils of treated and control fields before harvest and three months after harvest. Densities of *Aspergillus* species and frequencies of the strains composing both Aflasafe products will be determined in crops at the time of harvest. In addition, aflatoxins will be quantified in treated and control fields to determine efficacy of both Aflasafe products in reducing aflatoxin accumulation.

These field efficacy data will be used for the preparation of dossier to facilitate registration of the Aflasafe products as bio pesticides.

Sub-activity RT5-Gh-3.4: Carry-over of atoxigenic strains of Aflasafe products from one season to the next and its cumulative impact on aflatoxin reduction 1–3 years after Aflasafe application

In this activity, the frequency of application of Aflasafe GH01 or Aflasafe GH02 over 3 consecutive growing seasons in the Northern Region in farmers' fields will be continued for the second year in 2016. One hundred and twenty (120) maize fields comprising 60 fields per Aflasafe product selected in the previous year will be used for this trial. These will be subdivided into 6 treatments of 10 fields each. In treatment 1, fields will be treated in alternate years with Aflasafe GH01 or Aflasafe GH02 within the period of the experiment. In treatment 2, fields will be inoculated consecutively in all three growing seasons. Fields in treatment 3 will be inoculated only in the first and second growing season while in treatment 4 inoculations will be carried out only in the first growing season. Fields in treatment 5 will be inoculated only in the third year while fields in treatment 6 will serve as control with none of the fields inoculated throughout the study period.

Data collection: Field soil samples and crop (grain) samples will be collected in each growing season for microbial and chemical analyses. Frequencies and densities of strains composing Aflasafe products in both soils and crops at harvest will be assessed. Aflatoxins will be quantified in crops harvested from all treatments.

In addition to the 240 fields in the Africa RISING areas in northern Ghana mentioned above (funded by Africa RISING), efficacy trials will also be conducted in the Middle Belt (funded by another complementary project – the Meridian/PACA/BMGF regional biocontrol development). The country-wide efficacy trials are required to determine the efficacy of biocontrol in several agro-ecozones.

Sub-activity RT5-Gh-3.5: Scaling out of Aflasafe technology innovation (expansion) in partnership with SPRING/Ghana (a USAID funded nutrition project)

In collaboration with SPRING/Ghana, Aflasafe technology will complement with other activities (initiatives) for improving household nutrition and value addition in northern Ghana. Linkages and contacts have been made with SPRING/Ghana on use (scaling up) of Aflasafe in communities of SPRING/Ghana. Common interest and partnership between IITA and SPRING/Ghana project was established. Aflasafe will be introduced in 150 farmer field school demonstration plots (61 ha) for the management of aflatoxin, across 15 districts in the Northern

and Upper East regions in 2016. SPRING/Ghana aims to improving household nutrition in two regions—Northern Region and Upper East Region. SPRING/Ghana expects IITA to pay for the product. It is estimated that 3,000 farmers will benefit from the activities conducted in the field school demonstration plots.

Data collection: Aflatoxins will be quantified in treated and control fields to determine efficacy of both Aflasafe products in reducing aflatoxin accumulation.

Sub-activity RT5-Gh-3.6: Combined pre- and post- harvest innovations

In partnership with the Feed the Future Reduction in Post-Harvest Losses Innovation Lab, options for minimizing postharvest losses and aflatoxin contamination in maize and groundnut through combining pre-harvest intervention using Aflasafe biocontrol and postharvest innovation will be identified and evaluated. Aflatoxin biocontrol activities will be linked with ICRISAT's work on aflatoxin resistant groundnut varieties and improved cultural practices to reduce aflatoxin accumulation. The pre-harvest activities will be linked with **Activity RT5-Gh-2 'Reducing postharvest losses in stored grains of cereals and legumes'** led by Asamoah Larbi and a consultant, and will be undertaken in collaboration with the Post-harvest Losses Innovation Laboratory, which will provide expertise in monitoring aflatoxin levels and research in drying technologies. The introduction of drying technologies will give farmers the opportunity to preserve the quality of their commodities by immediately drying grains to the appropriate moisture content. While Aflasafe minimizes pre-harvest aflatoxin contamination in maize and groundnut, effective drying with this innovation will help preserve grain quality and further minimize post-harvest crop losses.

Data collection: Aflatoxin concentrations will be quantified in all trials.

Sub-activity RT5-Gh-3.7: Inspection of Aflasafe efficacy trials in farmers' fields by Environmental Protection Agency (EPA) for its registration

Active partnership with Ghanaian regulatory authorities such as the EPA and PPRSD of MoFA has been built and will be further strengthened in 2016, to facilitate promotion and registration of the Aflasafe products in the future and strengthen national advocacy coalitions for supporting the process of product registration.

Linkages have been made with EPA who will be involved in monitoring Aflasafe product testing, aiming at promoting benefit of Aflasafe technology with regulators towards registration in Ghana; this is a prerequisite for product registration. A consultation visit and meeting was made and held with the Director of EPA to facilitate the inspection and registration process of technology. During this visit in Ghana, we had the opportunity to i) introduce in details Aflasafe biocontrol technology and at the same time receiving EPA technical guidelines and requirements for field efficacy inspection and registration, ii) setup an action plan for the inspection of Aflasafe field efficacy trials in 2016, and iii) obtain permission from the regulatory body EPA to treat 4,000ha with Aflasafe products in 2016. We will organize visits of EPA and PPRSD officials to a few efficacy trial sites to enable these officials to understand the nature and application of the technology.

Data collection: Cropping system, method of application, crop appearance, sex and age of the farmers.

Deliverables		Date (2016)
1	Recovery of Aflasafe biocontrol strains and aflatoxin analyses completed for 1,000 samples obtained from field efficacy evaluation trials of Aflasafe GH01 and Aflasafe GH02 conducted across Ghana in 2015	Jun
2	Up to 50 trainers (30 health personnel and 20 AEAs & Field technicians including lead farmers) trained on the health impacts of aflatoxins and its management who in turn train over 950 farmers with at least 40% women farmers and trainers	Jul
3	Efficacy validation trials of Aflasafe GH01 and Aflasafe GH02 in more than 200 fields	Jul-Nov
4	Carry-over trials of atoxigenic strains of Aflasafe products after Aflasafe application in 120 fields	Aug-Nov
5	Aflasafe technology scaled up in partnership with SPRING/Ghana (a USAID funded nutrition project) and Groundnut Scaling project; data on number of households applying Aflasafe products will be collected	Jul-Oct
6	Benefits of combined pre- and post- harvest innovations determined	Oct
7	Environmental Protection Agency (EPA) officials will inspect Aflasafe efficacy trials in farmers' fields for its registration in Ghana	Jul-Nov
8	At least one manuscript drafted and submitted: Biocontrol of aflatoxins in maize and groundnut with Aflasafe GH01 and Aflasafe GH02: two bio pesticides developed for Ghana (Journal: Plant Disease)	Dec

4. Expected outcomes		2014	2015	2016
1	Households are adopting behaviors to improve dietary diversity	x	x	x
2	Caregivers/women apply their nutritional skills in food preparation	x	x	x
3	Households adapt technologies that reduce post-harvest losses		x	x
4	Extension officers have included aflatoxin management in their messages		x	x
5	Households have adopted measures to reduce aflatoxin in maize and groundnut		x	x

5. Budget (US\$x1000)

Theme/Activity	Budget Line	IITA	UDS	MoFA ¹	AGRIMAT ¹	UG ¹
RT5-Gh-1	Personnel	5	8	8		
	Services	4	4	4		
	Supplies	3	3	3		
	Travel	3	5	5		
RT5-Gh-2	Personnel	28			5	5
	Services	15			4	4
	Supplies	33			3	3
	Travel	10			3	3
RT5-Gh-3	Personnel	35				
	Services	15				
	Supplies	40				
	Travel	10				
	Total	201	20	15	15	15
	Grand total	266				

¹Budget allocations to MoFA, AGRIMAT and UG to be retained by IITA and paid to the partner and graduate students directly upon implementation of activities.

Table 2: 2016 Activity-based Budget - Africa RISING Ghana

Theme/Activity	Activity Leader	Tentative partner budget (US\$x1000)										
		IITA	ILRI	CIAT	IWMI	AVRDC	SARI	UDS	KNUST	MOFA	UG	AGRIMAT
	Partnerships and socio-economic assessment											
1.1	Mobilize communities and facilitate R4D platforms	IITA/MOFA (Asamoah)	50							20		
1.2	Economic validation and monitoring of adoption	IITA (Bekele)										
1.3	Farming systems analysis	WUR (Jeroen)										
1.4	Gender mainstreaming	IITA (Gundula)										
1.5	In-country research management	IITA (Asamoah)	40									
	Intensification of cropping and crop-livestock systems											
2.1	Intensifying cereal-legume production and integrated crop-livestock	IITA/MOFA (Asamoah)	250							15		
2.2	Integrated soil fertility management	SARI (Saaka Buah)					50					
2.3	Intensification of rainfed and irrigated vegetable production	AVRDC (Jean-Baptiste) ¹				84		10	15			5
	Intensive livestock production											
3.1	Feed and health intervention to improve small ruminant production	ILRI (Augustine)		170								
3.2	Intensive poultry, pig and integrated poultry/pig-crop systems	UDS/IITA (Dei/Asamoah)	27					23	25	20		
	Land, soil and water management											
4.1	Testing small-scale irrigation options for dry season vegetables	IWMI (Davie)		50								

4.2	Exploring potential supplementary irrigation in rain-fed crop-livestock systems	IWMI (Davie)			50					10			
4.3	Piloting a combination of soil and water management strategies	CIAT (Fred) ²				50							
4.4	Farmer recommendation and trade-off analysis	CIAT (Fred)				50							
	Nutrition, food storage, value addition and mycotoxin management												
5.1	Improve household nutrition	UDS/MOFA (Mahama)							20		15		
5.2	Reducing post-harvest losses in stored grains	IITA (tbd)	86								10	15	15
5.3	Biological control of aflatoxins in maize and groundnut with Aflasafe	IITA (Gasim)	100										
		Total	553	170	100	100	84	50	53	50	80	15	20
Grand total			1275										

¹US\$ 40,000 of the AVRDC budget allocation to be retained by IITA for salary and operation of research assistant hired by IITA for AVRDC.

²US\$ 40,000 of the CIAT budget allocation to be retained by IITA for salary and operation of research assistant hired by IITA for CIAT.

3. Mali work plan

Theme 1: Partnerships and socio-economics of intensification (RT1-Ma)

1. Research team

<i>Name</i>	<i>Institution</i>	<i>Degree</i>	<i>Research interest</i>	<i>Role</i>
Joachim Binam	ICRAF	PhD	Policy	Leader, RT1-Ma-1
Bougouna Sogoba	AMEDD	MSc	Rural development	Deputy leader, RT1-Ma-1
Birhanu Zemadim	ICRISAT	PhD	Land/Water management	Coordination
Bekele Kotu	IITA	PhD	Agricultural economics	Leader, RT1-Ma-1.2
Toumani Sidibe	MOBIOM	MSc	Training	Monitor meetings
Catherine Dembele	ICRAF	PhD	Agroforestry	Managing trials
Ousmane Sanogo	IER	PhD	Farming systems	Market studies
Katrien Descheemaeker	WUR	PhD	Farming systems	Farming systems analysis
Mary Ollenburger	WUR	MSc	Farming systems	Managing trials
Felix Badolo	ICRISAT	PhD	Agricultural economics	Socio-economic studies
Mahamadou Dicko	ICRISAT	MSc	Site coordination	Bougouni site coordinator
Karamoko Traore	ICRISAT	MSc	Site coordination	Koutiala site coordinator

2. Objectives

- 1 Promote new demand-driven extension approaches to enhance adoption of technologies by farmers
- 2 Conduct a stakeholder analysis to analyze existing stakeholders and their interests
- 3 Strengthen capacity of stakeholders on innovation system approaches
- 4 Study the role of social networks in innovation systems and their impact on adoption of technologies

3. Activities

Activity RT1-Ma-1	Establishment and characterization of R4D platforms	
Lead scientist(s)	Joachim Binam	Institution: ICRAF
Other scientist(s)	Bougouna Sogoba	
Location(s)	Bougouni and Koutiala Districts	

Procedures

Sub-activity RT1-Ma-1.1: Facilitation, monitoring and evaluation of existing R4D platforms

Monitoring and evaluation data will be collected frequently from the main actors involved in the already existing R4D platforms in Koutiala, Bougouni, M'pessoba and Flola. Monitoring and Evaluation (M&E) tools will be used to gather the required data. They will then be analyzed to appreciate the effectiveness and efficiency of the platforms. In addition, two more commune-level

platforms will be established to support the projected Technology Parks planned to be set-up in 2016. It will also involve feedback session for the 2016 annual work plan with the platforms in Bougouni and Koutiala.

Sub-activity RT1-Ma-1.2: Capacity building of partners on stakeholder mapping, engagement and management

Africa RISING project in Mali is toward the completion of its first phase and is initiating an exit strategy by proposing a second phase implementation programme. Within the first phase, some technologies and practices were trialled and baseline and characterisation studies completed. Some stakeholders were identified but this list is not exhaustive and stakeholders and their relationships were not properly analysed. Stakeholder analysis can help to understand the different perceptions and interests of stakeholders at different levels, and how they may influence environmental and developmental interactions and outcomes. As such, stakeholder mapping and analysis for the coming agenda offers an opportunity to enhance Africa RISING implementation and can:

- Be a first step to improving local governance and institutional capacity building.
- Provide a process for interaction with the community and other stakeholders to identify additional sources of information and other resources to support programme implementation.
- Determine where stakeholder relationships need to be improved, amended or created.
- Identify existing major communication systems for the different groupings within the programme areas.
- Promote greater understanding and clarity of the communities' needs and capabilities.
- Identify potential opportunities and threats to the programme interventions including bottlenecks.
- At a programmatic level, can identify important scaling partners and policy influencers to be engaged such that policy change and scaling out can be maximised.
- Advise on the extent to which certain groups should or could participate in planning, implementation and evaluation of the programme.
- Provide information to support learning and consensus building amongst stakeholders.
- Identify key and less powerful or marginal stakeholders to engage in decision making.

A technical guide/manual will be developed and finalized and shared with different actors as a support tool for another two or three-day 2016 complementary training workshop to the first one planned in 2015 work plan.

Sub-activity RT1-Ma-1.3: Multi-stakeholder national workshop for feedback on results of the different work packages

A two-day workshop will be organized in Bamako in April 2016 to present recent findings to partners and adjust plans accordingly to improve integration and synergies. The first day is reserved for presentations, while the second day will allow for adjusting plans, improving integration and identification of synergies. On the first day, the leader or deputy leader of each activity will present the general results; while one to three presentations per activity will allow for detailed information on results and lessons learnt. This will lead to four short activity presentations and between four to eight in-depth presentations with discussions. Researchers, local partners and farmers will have stands to demonstrate different available technology options. Local radio, technical services from the region, etc., etc., will be invited.

On the second day, opportunities and constraints arising from the presentations will be identified and work groups will be formed to articulate how these can be dealt with and how we can ensure synergies between activities within a given activity and between activities. Workshop will particularly include women and youth.

Sub-activity RT1-Ma-1.4: Establish and assess impact of R4D Platforms on technology adoption

Methodological and capacity building workshops on R4D platforms and kick-off meetings will be organized for the establishment of platforms linked to the 2016 newly established technology parks. The implementation process will be reviewed and lessons learnt documented. Participatory approaches will be used to monitor and evaluate the activities of the R4D platforms. A one week write shop will be organized in Koutiala to carry out greater analysis from the existing 250 household level data to ascertain the role of rural social networks and their impact on the adoption of sustainable innovations being promoted within the framework of Africa RISING. Two publications will be prepared and submitted to peer-reviewed journals by end July 2016.

Deliverables		Date (2016)
1	Technical/training guide on stakeholder mapping and analysis	May
2	Training report on mapping, engagement and analysis	May
3	Stakeholder maps showing social networks and relationships	Aug
4	Guides and protocols on stakeholder analysis, engagement and management	Jul
5	One publication to be submitted to peer-reviewed journal on impact of R4D platforms on technology adoption	Jul
6	One publication to be submitted to peer-reviewed journal on social networks and power dynamics	Jul
7	Socioeconomic and network data uploaded to CKAN	Sep

Activity RT1-Ma-2

	Project coordination and facilitation of activities in the Technology Parks	
Lead scientists(s)	Birhanu Zemadim	Institution: ICRISAT
Other scientist(s)	Bougouna Sogoba, Mahamadou Dicko, Karamoko Traore, Cedrick Guedessou, Marc Traore	
Student(s)	Mary Ollenburger	
Location(s)	Koutiala and Bougouni Districts	

Procedures

Mali project coordination is done by ICRISAT in close collaboration with partner institutes. Two Technology Parks were established in Bougouni (Flola village) and Koutiala (M'pessoba village). The parks have been used by participating institutes (ICRISAT, ICRAF, AVRDC and IER) to conduct controlled research experiments. Training programs have been conducted in the parks for local NGOs, national training centers and communities living in Africa RISING intervention villages. The parks have been used by other programs, like West Africa sorghum improvement program, groundnut improvement program for capacity building and outreach activities which include men and women and youth. In addition, the establishment of the two parks has avoided independent research and capacity building activities by partner institutes. However depending on the scattered nature of community settlements, the two parks were limited to fully reach the

communities in the intervention villages. Thus two more parks were proposed during the external evaluation mission commissioned by USAID, one for each district. The Chief Scientist of the program for West Africa also proposed better management of the parks through providing a pick-up with driver in each district. However due to budget constraint these new additional plans were postponed for the second phase of the program.

Organizing a farmer field day for exchange and co-learning. Exchanges within and between districts is a learning experience for farmers and researchers. It will be ensured that a diverse group of farmers is represented in capacity building activities (youth and women, different types of farmers e.g. CMDT type A-D) and that their perceptions are captured.

Data collection: Soil moisture, runoff, erosion, agronomic, climate data, socio-economic data (e.g. farmer perceptions of technologies disaggregated by village, sex, age, by farm type).

Deliverables		Date (2016)
1	Data on improved technologies and participatory research collected and uploaded to the CKAN repository	Dec
2	Reports on capacity building activities in the technology parks including numbers of participants made available to project partners and shared through the Africa RISING wiki	Aug
3	Video documentation of activities implemented in the technology parks	Dec
4	Report on farmer perception of technologies from the field visit	Sep

Activity RT1-Ma-3	Monitor market prices and characterize value chains	
Lead scientist(s)	Felix Badolo and Bougouna Sogoba	Institution: ICRISAT, AMEDD
Other scientist(s)	Ousmane Sanogo, Birhanu Zemadim, Mahamadou Dicko, Karamoko Traore	
Student(s)		
Location(s)	Koutiala and Bougouni Districts	

Procedures

Sub-activity RT1-Ma-3.1: Quarterly monitoring of prices of agricultural products in three large, weekly markets in Koutiala and Bougouni

A data collection protocol will be shared with partners for comments and validation. With input from local partners, three major markets will be identified for the study in the Koutiala and Bougouni areas. The validated protocol is then used to survey and monitor market prices on a quarterly basis for a period of two years. Data will be entered and presented in tabular form every 3 months and a synthesis of results and main conclusions are presented in a short report every year from the start of monitoring. This information is used whenever necessary (in the R4D platform meetings, in the country meetings, during feedback sessions and cost-benefit analyses with farmers and for farm system analyses).

Data collection: Market prices of technology components.

Sub-activity RT1-Ma-3.2: Value chain studies on at least three value chains identified by the R4D platforms

The R4D platforms at the district level will identify promising value chains on which analyses will be performed. Analyses will be conducted by Felix Badolo, results shared and validated in district level and national level meetings. Value chain studies will include gender analysis.

Data collection: Production data, market data, data on transformation of products

Deliverables		Date (2016)
1	Quarterly report on monitoring prices of agricultural products	Aug
2	Market price data will be uploaded to CKAN	Dec
3	Technical report on value chain analysis	Aug
4	Technical report on cost benefit analysis of Africa RISING technologies	Jul

Activity RT1-Ma-4	Economic validation of sustainable intensification options	
Lead scientist(s)	Bekele Kotu, Felix Badolo	Institution: IITA, ICRISAT
Other scientist(s)	Ousmane Sanogo	
Location(s)	Koutiala and Bougouni Districts	

Procedures

Sub-activity RT1-Ma-4.1: Economic validation of improved agricultural technologies

A number of technologies are being identified in biological trials in Mali. However, socio-economic information about the technologies is lacking. The study aims to evaluate selected technologies from the socio-economic point of view. It will involve: 1) providing socio-economic input to publication of completed studies; 2) collection and analysis of data on on-going trials; and 3) in-depth socio-economic assessment of selected technologies.

Sub-activity RT1-Ma-4.2: Monitoring adoption of Africa RISING technologies in Mali

Since the inception of the Africa RISING project, several technologies have been identified and introduced to smallholder farmers in the target areas of the project. The project has adopted new approaches such as the mother-baby trials and the innovation-platforms. These new approaches are expected to enhance the intensification of smallholder agriculture in the target areas thereby improving the well-beings of farmers. However, the realization of this outcome is not automatic and there may be obstacles that would operate against the initial expectations. This study is designed to provide analytical information on the adoption of technologies generated and promoted by the Africa RISING (AR) project. It will assess how well the technologies are being adopted by the farmers. It will also examine, through a network mapping, who is using which technologies or elements of technologies, where, why and how these are being modified by different farmer or household categories. It can be considered as an ongoing evaluation of the adoption process. This study will depend mainly on a household survey.

Data collection: Agronomic data, socio-demographic data, crop production, application of Africa RISING technologies, and household resource endowments (among others).

Deliverables

1	Technical report on adoption of technologies in Africa RISING communities in Mali	Date (2016) Dec
2	Journal article submitted on analysis of early adoption of technologies tested by the Africa RISING project in Mali	Dec

4. Expected outcomes

		Short	Medium	Long
1	Increased interaction among stakeholders through the R4D platforms	x	x	
2	Research institutions use R4D platforms and less of the linear research – extension approach		x	x

5. Budget (US\$x1000)

Theme/Activity		ICRISAT	ICRAF	AMEDD	IER
RT1-Ma-1	Personnel		25	10	
	Services			5	
	Supplies		6.5	1	
	Travel	3	20	4	
	Sub total	3	51.5	20	
	Overhead	0.474	8.137	3.160	
	Total	3.474	59.637	23.160	
RT1-Ma-2	Personnel	150			
	Services	30			
	Supplies	60			
	Travel	10			
	Sub total	250			
	Overhead	39.500			
	Total	289.5			
RT1-Ma-3	Personnel	5			3
	Services	2			5
	Supplies				1
	Travel	5			3
	Sub total	12			12
	Overhead	1.896			1.896
	Total	13.896			13.896
Grand Total		403.563			

Theme 2: Intensification of cereal-legume-vegetable cropping systems (RT2-Ma)

1. Research team

<i>Name</i>	<i>Institution</i>	<i>Degree</i>	<i>Research interest</i>	<i>Role</i>
Ramadjita Tabo	ICRISAT	PhD	Agronomy	Leader, RT2-Ma-1
Birhanu Zemadim	ICRISAT	PhD	Land and water	Coordination
Jean-Baptiste Tignegre	AVRDC	PhD	Vegetable breeding	Leader, RT2-Ma-2
Ipha Sidi Traoré	AVRDC	MSc		Managing trials
Catherine Dembele	ICRAF	PhD	Agroforestry	Leader, RT2-Ma-3
Fatoumata Traoré	ICRAF	BSc	Leafy vegetables	Monitoring trials
Mary Ollenburger	WUR	MSc	Farming systems	Managing trials,
Princess Adjei-Frimpong	MSU	MSc	Agronomy	Field implementation
Ousmane Sanogo	IER	PhD	Farming systems	Market study
Katrien Descheemaeker	WUR	PhD	Farming systems	Farming systems analysis
Joachim Binam	ICRAF	PhD	Socio-economy	Economic evaluation
Odjouma Samaké	ICRAF	MSc	Agroforestry	Managing trials
Bréhima Koné	ICRAF	MSc	Agroforestry	Managing trials
Haile Desmae	ICRISAT	PhD	Breeding	Managing trials
Dekoro Dembele	ICRISAT	MSc	Breeding	Managing trials
Caroline Sobgui	AVRDC	PhD	Nutrition	Leading nutrition activities
Moussa Kanoté	AVRDC	MSc	Nutrition	Assisting nutrition studies

2. Objectives

1. Evaluate the impact of participatory varietal testing in combination with improved crop management options on the demand for and sales of agricultural inputs and seeds of improved varieties of a range of crops (vegetables, field crops and tree seeds/seedlings/grafts)
2. Facilitate access to knowledge and information about markets, options, integrated innovations and inputs for sustainable intensification in order to encourage adoption
3. Strengthen the capacities of local stakeholders (farmers, extension and research staff...) in evaluating and testing sustainable innovation options associated with farm system components
4. Test and evaluate the productivity and profitability of combinations of intensification options (improved varieties, hybrids, fertilizer application, (bio)pesticides, intercropping etc.) at the field scale
5. Test and evaluate the productivity and profitability of intensified livestock feeding options (stable feeding of small ruminants and dairy cows)

6. Feedback and discuss results of experimentation with participating farmers in participatory sessions in the villages and to a wider audience through the different platforms
7. Identify and disseminate suitable cultivars or genotypes and efficient cultivation practices for intensive fruit production of *Ziziphus mauritiana*, *Tamarindus indica*, *Adansonia digitata* and *Vitellaria paradoxa* systems
8. Identify tree species efficient for improving soil fertility, water conservation and fodder production
9. Assess productivity and profitability of existing mixed cereal/legume-vegetable configurations
10. Collect quality data for parameterization of the farm systems components and the whole farm system
11. Parameterize models and determine efficiency with different combinations of intensification options

3. Activities

Activity RT2-Ma-1

Intensifying productivity of cereal-legume cropping systems

Lead scientist(s)

Ramadjita Tabo

Institution: ICRISAT

Other scientist(s)

Haile Desmae, Dekoro Dembele, Birhanu Zemadim

Student(s)

Mary Ollenburger

Location(s)

Koutiala and Bougouni Districts

Procedures

Sub-activity RT2-Ma-1.1: Analyze data and develop models based on farm characterization data and cereal-legume experiments conducted in 2013, 2014 and 2015

Data will be cleaned and analyzed. Summarized results will be presented in project reports, shared with AR team and presented to farmers and local stakeholders in the AR villages. The effects of different combinations and scenarios of intensification options on farm efficiency, productivity and land use in different scenarios of socio-economic and biophysical developments will be simulated (ex-ante analysis). These results will be published in a peer-reviewed journal (planned: Experimental Agriculture, Contested Agronomy Special Issue to be submitted in June).

Sub-activity RT2-Ma-1.2: Organize feedback sessions with stakeholders

Feedback sessions will be organized in the intervention villages to present and discuss the results with local partners and farmers. The feedback sessions will consist of (1) presentation and discussion of agronomic results, and (2) identification of labor requirements for different treatments and cost-benefit analysis of one or more type of trials. Farmer preferred varieties of cereals, grain legumes and vegetables will be identified and plans made to make seeds available for sale through the partners in the R4D platforms.

Sub-activity RT2-Ma-1.3: Conducting on-farm participatory variety selection trials and groundnut varieties demonstrations in Koutiala and Bougouni districts

The objective here is to enhance production and productivity of groundnut in Mali through utilization of improved varieties and production technologies. It is envisaged that over 1000 households will benefit from the planned activities. The program involves implementation of activities in collaboration with local NGOs: AMASSA, CAAD and GRAADECOM. The work involves provision of groundnut seeds and on-farm trials protocols to these NGOs. Training is another component of the work and is provided to local farmers and technical staff of partner institutes on the implementation

and management of the on-farm trials. Field trip will also be organized to assess the progress of trials and field days will also be organized by the partners and ICRISAT. Similarly, farm participatory evaluation in field will be conducted to enable farmers select preferred varieties; training on postharvest management and aflatoxin management will be provided and finally qualitative and quantitative data will be collected and analyzed.

Procedure:

1. 5 mother trials and 25 baby trials will be conducted
2. A demonstration plot in the technology Park of M'pessoba;
3. Conduct training on good agronomic practices and Aflatoxin management;
4. Conduct post-harvest training;
5. Farmer field days organization

Data collection: Quantitative: days to emergence, days to flowering, early leaf spot, late leaf spot, days to maturity, number of plants at harvest, pod yield and haulm yield, (ii) qualitative (subjective data): farmers ranking of varieties, ranking criteria, and other feedbacks.

Sub-activity RT2-Ma-1.4: Evaluating different cropping systems and their water use efficiencies in Koutiala and Bougouni districts

Water use efficiency (WUE) is an important determinant of crop productivity in water limited environment. Cereal-legume associations have been shown to improve WUE due to differences in rooting pattern of component species resulting in complimentary resource use. Pigeon pea, a semi-perennial legume has the hydraulic lift potential which makes the crop adaptable to highly variable rainfall conditions.

However, it is not well established whether pigeon pea is able to hydraulically lift water as a sole crop or as intercrop, and whether this water lifting makes the plant water use efficient. The objective of this work is to determine the soil moisture distribution in the root zone of sorghum and pigeon pea, and assess the effect of cropping system and soil nutrient on sorghum-pigeon pea yields and WUE.

Field trials will be established in these two districts in a randomized complete block design with 4 replications, two cultivars of pigeon pea and sorghum. Access tubes will be installed within rows of plots to a depth of 100 cm in some selected treatments. Soil moisture content will be monitored at different stages of plant growth during the growing season. Grain yield and biomass assessment will be taken at the vegetative, flowering and physiological maturity stages of crop growth. Grain yield and soil moisture data will be used to quantify which cropping system is water use efficient.

Data collection: Soil moisture at different stages of plant growth, grain yield, biomass at different stages of plant growth.

Deliverables		Date (2016)
1	Bougouni 2015 data on agronomic trials available on CKAN	Apr
2	Report on participatory selection of groundnut	Dec
3	Report on Water Use Efficiency of cereal-legume associations	Oct
4	Report on training on groundnut intensification	Aug
5	Database of PVS 2014-2016 available on CKAN	Dec
6	Manuscript on promising technologies (Haile)	Jul
7	Journal article on Solution Spaces for Sustainable Intensification submitted to Experimental Agriculture	Jul

Activity RT2-Ma-2	Improving productivity and profitability of cereal/legume-vegetable systems	
Lead scientist(s)	Jean-Baptiste Tignegre	Institution: AVRDC
Other scientist(s)	Alpha Sidi Traoré, Ousmane Sanogo, Caroline Sobgui, Moussa Kanouté, Felix Badolo	
Location(s)	Koutiala and Bougouni districts	

Procedures

Sub-activity RT2-Ma-2.1: Data analysis and publication of results from completed experiments

Analyze data from experiments conducted from 2013-2015 and publish results in peer reviewed journals.

Sub-activity RT2-Ma-2.2: Disseminate promising technologies conducted over past two years (2014-2015) to intensify vegetable mono-cropping in cereal-based crop systems in off-season

As this activity requires off-season infrastructure (fencing and well), only those villages with infrastructure will be concerned (Yorobougoula and Sibirila in Bougouni District and Sirakele, Zanzoni and M'pessoba in Koutiala District). Participatory testing and diffusion of promising new vegetable cultivars will be carried out to deliver high value, multiple disease-resistant and nutrient-dense vegetable cultivars in the off-season. Vegetable mono-cropping will be implemented with disseminations of farmers' preferred vegetable varieties and species. Seed production will be initiated to sustain availability in the communities.

Twelve farmers (households) per village in each of five action villages in each of the Bougouni and Koutiala districts (total of 60) will be selected to participate in testing and diffusion of the four most popular vegetable crops (okra, pepper, tomato and sorrel). In each of the five target actions villages, the vegetable crops chosen will be compared across subsets of 10 households per village (depending on crop preference and seed availability) using two planting densities (farmer practice vs. recommended practice).

Data collection: Yield, market value and utilization (contribution to dietary diversity) of the tested vegetables. It is intended that this work will form part of the thesis research of an MSc student to be identified.

Sub-activity RT2-Ma-2.3: Assess productivity and profitability of promising technologies for an early vegetable production in pure stands

The trial will be conducted in Madina and Dieba (Bougouni District) and Sirakele, Zanzoni and M'pessoba (Koutiala District). The best species for early production such as tomato, cabbage, onion, okra and African eggplant will be evaluated. A second year for dry season vegetable early planting trials will continue in 2016 to confirm data collected earlier in 2015 for publication. This will require access to water from wells, rivers, dams and rainwater harvesting and exploring wetland use.

Fifteen farmers (households) per village in each of five action villages, including 50% of women in each of the Bougouni and Koutiala districts (total of 75) will be selected to participate in testing and diffusion of the four most popular vegetable crops (okra, pepper, tomato and sorrel). In each of the five target actions villages, the vegetable crops chosen will be compared to the local controls in pure stands using AVRDC recommended practices.

Data collection: Agronomic data (yield), market value, utilization

Deliverables		Date (2016)
1	Report on dissemination of vegetable production technologies	Dec
	Report on seed production activities	Dec
2	Farmers have been exposed to a variety of legume species in pure stand in 10 villages	Feb (2017)
3	Report on profitability of dry vegetable production	Sep
4	Article on intensification of vegetable and maize intercropping systems	Dec
	Article on intensification of vegetable production in the cold dry season	Dec

Activity RT2-Ma-3	Agroforestry options for intensive fruit, vegetable and fodder production	
Lead Scientists(s)	Catherine Dembele	Institution: ICRAF
Other scientist(s)	Joachim Binam, Odjouma Samake, Brehima Kone	
Student	Traoré Fatoumata	
Location(s)	Koutiala and Bougouni districts	

Procedures

Sub-activity RT2-Ma-3.1: Monitor fruit tree establishment trials established in 2013, 2014 and 2015 for intensive fruit production

In August 2013, a trial was established on intensive production of fruits from 7 cultivars of *Ziziphus mauritiana* (Ben Gourrion, Gola, ICRAF6, ICRAF8, ICRAF9, Kaithly, and Umran), 3 superior genotypes of *Tamarindus indica* (Niger 309, Thai sucré, Thai gros fruit), 1 genotype of *Adansonia digitata* (Nonokene) and 1 genotype of *Vitellaria paradoxa* (Samanko-ka). The objective was to determine the effect of manure fertilization and farmer's choice of irrigation management on the growth and fruit production of 12 cultivars and genotypes from 4 fruit tree species indigenous to the Sahel. Two replicates of 3 grafted plants for each cultivar or genotype were planted in 5 villages retained for the intervention. These are M'pessoba, Sirakele and Zanzoni in Koutiala District and Sibirila in Bougouni District. Plant growth and fruit production will be monitored from 2013 to 2016. Data will be cleaned and analyzed for reporting and publication.

Sub-activity RT2-Ma-3.2: Intensive leafy vegetable production from Adansonia digitata (baobab) and Moringa oleifera

Baobab and *Moringa* are two tree species producing high value vegetable for human nutrition. The leaves, rich in calcium and good quality protein, are used green or dried as vegetables everywhere in the Sahel zone in Africa. However, leaves are collected mainly during the rainy season. In order to get fresh leaves year round, intensive method of cultivation is suggested using fertilization and irrigation in each of the 5 target villages. Leaf biomass production monitored from 2014 to 2016 will be analyzed for reporting and publishing. This activity will be linked to nutrition (Theme 5: sub-activities 5.1 and 5.2) by raising awareness of the nutritional benefits of *Moringa* and baobab and testing ways of using the leaves in a variety of recipes.

Sub-activity RT2-Ma-3.3: Improving soil fertility using fodder and fertilizer tree species

Four fertilizer and fodder tree species trials (*Acacia angustifolia*, *Acacia coleii*, *Gliricidia sepium*, *Calliandra calothyrsus*, and *Piliostigma reticulatum*) established in 2014 and 2015 on farmers' fields and the Technology Parks will be monitored. Data collected will be analyzed for reporting. *A. coleii*, *G. sepium* and *P. reticulatum* will be established along the contour bands that will be established in two Technology Parks planned for 2016 in collaboration with scientists from AVRDC and ICRISAT.

Sub-activity RT2-Ma-3.4: Monitor improved fruit and vegetable trees established within Technology Park and farmers' field in 2015

Within the 2 Technology Parks in M'pessoba and Flola, superior accessions of *Tamarindus indica*, *Adansonia digitata* and cultivars of *Ziziphus mauritiana* have been established along with vegetable crops in collaboration with AVRDC in the technology parks and in farmers' fields. Data obtained will be analyzed and reported. Similar trials with improved fruit and vegetable trees will be established in the two Technology Parks that will be constructed in 2016 in collaboration with scientists from AVRDC and ICRISAT.

Sub-activity RT2-Ma-3.5: Design household fruit and vegetable tree garden for enhancing household nutrition

Volunteer household will be supported to propagate and plant fruit and vegetable trees on small plots (30 m²) for vegetable and fruit production at household level.

Sub-activity RT2-Ma-3.6: Train volunteers for nursery plant propagation by seeds and grafting for private plantation

Volunteer farmers of the 10 villages will be trained and supported for seedling propagation and grafting in nursery in order to allow them to continue tree planting after the end of the Africa RISING project.

Sub-activity RT2-Ma-3.7: Survey to assess the opinion of farmers that have been involved in the activities of agroforestry about the different technologies established

Farmers will be interviewed individually and in groups to assess their view point about all agroforestry technologies established: 12 cultivars of 4 fruit species (*A. digitata*, *T. indica*, *V. paradoxa* and *Z. mauritiana*), 2 vegetable tree species (*A. digitata* and *M. oleifera*) planted in fruit and vegetable tree gardens and the Technology Parks, fodder and fertilizer tree species (*A. angustifolia*, *A. coleii*, *G. sepium*, *C. calothyrsus*, and *P. reticulatum*) planted on contour bands.

Data collection: (i) Data regarding phenology: leaving, flowering, and fruiting to follow the early fruiting capacity of the grafted plant material we have planted, (ii) Growth: height, collar diameter, canopy width (North – South, East – West), (iii) Farmers’ opinion: a survey on farmers’ opinion on our work in general and especially the accessions of vegetable and fruit tree species.

Deliverables		Date (2016)
1	Paper on growth parameters and phenological stages of fruit trees	Oct
2	Manuscript on growth parameters and leaf biomass of vegetable trees	Oct
3	Report on biomass production of fertilizer trees	Oct
4	Survey report	Sep

4. Expected outcomes		2014	2015	2016
1	Farmers are adopting improved cereal-legume-vegetable cropping	x	x	x
2	Farmers are integrating trees and shrubs into their cropping systems		x	x

5. Budget (US\$x1000)

Theme/Activity		ICRISAT	ICRAF	AVRDC	CAAD	GRADCOM
RT2-Ma-1	Personnel	5			3	3
	Services	1			2	2
	Supplies	1			1.5	1.5
	Travel	5			1.5	1.5
	Sub total	12			8	8
	Overhead	1.896			1.264	1.264
	Total	13.896			9.264	9.264
RT2-Ma-2	Personnel			35		
	Services			5.847		
	Supplies			5		
	Travel			5		
	Sub total			50.847		
	Overhead			9.153		
	Total			60		
RT2-Ma-3	Personnel		20			
	Services		8			
	Supplies		8			
	Travel		14			
	Sub total		50			
	Overhead		7.9			
	Total		57.9			
Grand Total			150.324			

Theme 3: Intensive livestock production (RT3-Ma)

1. Research team

<i>Name</i>	<i>Institution</i>	<i>Degree</i>	<i>Research interest</i>	<i>Role</i>
Augustine Ayantunde	ILRI	PhD	Animal husbandry	Leader, RT3-Ma-2
Sapna Jarial	ICRISAT	PhD	Crop-livestock	Leader, RT3-Ma-1
Anthony Whitbread	ICRISAT	PhD	Farming systems	Supervision RT3-Ma-1
Ramadjita Tabo	ICRISAT	PhD	Agronomy	Supervision RT-3-Ma-1
Hamidou Natoume	IER	PhD	Animal nutritionist	Field implementation
Clarisse Umutohi	ILRI	MSc	Natural Resource Policy	Graduate student
Bougouna Sogoba	AMEDD	MSc	Natural resource management	Local partner
Intern	ICRISAT	BSc	Agronomy	Graduate student

2. Objectives

- 1 Test options to improve feed from cereal-legume intercropping systems
- 2 Study gender preferences for feeding strategies and technologies
- 3 Demonstrate use of feed choppers
- 4 Study strengths and weakness of local conventions and identify options to strengthen them
- 5 Analyze causes of conflicts over natural resource use and options for participatory conflict management
- 6 Test feed and health interventions for improved sheep and goat production

3. Activities

Activity RT3-Ma-1	Improving feed resources production and use in mixed crop-livestock production systems		
Lead scientist(s)	Sapna Jarial	Institution: ICRISAT	
Other scientist(s)	Ramadjita Tabo, Anthony Whitbread, Hamidou Nantoume, Augustine Ayantude		
Students			
Location(s)	Dieba, Flola and Madina in Bougouni District and M’pessoba, Zanzoni, Sirakele and Nampossela in Koutiala District		

Procedures

Sub-activity RT3-Ma-1.1: Train and demonstrate use of a fodder chopper

This activity is to create awareness among farmers on the use of a fodder chopper for optimum and efficient use of fresh and dry fodder and analyze profitability of the technology. Members of farmer organizations, including fabricators, feed business persons, NGOs and staff of agriculture and animal husbandry department will be trained in the use of the fodder chopper and the potential business opportunities that it offers.

Sub-activity RT3-Ma-1.2: A national workshop to bring actors on livestock research in Mali. A one day workshop will be conducted in May 2016 to bring actors on livestock program in Mali. The outcome of the workshop help to synthesize livestock research approaches for the second phase of Africa RISING program.

Deliverables	Date (2016)
1 Report on crop-livestock trials and fodder chopper technology	Jul
2 Data on crop-livestock trials uploaded to CKAN	May
3 Data and report on gender preference to be uploaded on CKAN	May
4 Report on expert workshop on livestock research	Jun

Activity RT3-Ma-2	Documentation and validation of existing local conventions	
Lead scientist(s)	Augustine Ayantunde	Institution: ILRI
Student(s)	Clarisse Umutoni	
Location(s)	Koutiala, Bougouni/Yanfolila districts	

Procedures

Sub-activity RT3-Ma-2.1: Development and formalization of existing local conventions

Follow up activities will include: (i) Translation of the local conventions in the 3 communities into local languages (Bambara). (ii) Setting up of monitoring scheme to assess the impact of the newly formalized local conventions on natural resource management in the 3 communities. (iii) Building the capacity of the local surveillance committee through training and exchange visit to Yorosso Commune where the local conventions governing natural resource management were well developed. (iv) Preparation of policy brief on development and formalization of local conventions. (v) Preparation of a video on development processes of local conventions in 3 intervention communities.

Sub-activity RT3-Ma-2.2: Land use change analysis

To support the development and formalization processes of existing local conventions in the 3 intervention communities, map of land use change analysis will be developed for each community. The land use analysis will compare the changes in land use patterns between 1984 and 2009 using Landsat data. This analysis will provide insight and relevant information on changes in land use patterns in each community which can help to identify rules to be included in the local conventions for access and use of different land use types and ensure sustainable use of the natural resources in the community. As a follow up to the land use change analysis, a workshop will be organized to validate the land use change maps by the key opinion leaders in the 3 intervention communities (Dieba, Sirakele and Zanzoni).

Deliverables	Date (2016)
1 Translated local conventions in 3 communities in local languages	Jun
2 Policy brief on development and formalization of local conventions	Jul
3 Video on local conventions and livestock corridors: tools for peaceful management of natural resources	May
4 Report of validated land use change maps	Jun
5 Data on conflict management and transhumance uploaded to CKAN	July
5 Draft manuscript on analysis of conflict between farmers and herders in Southern Mali	July
6 Draft manuscript on farmer perceptions on transhumance practices	May

Activity RT3-Ma-3	Feed and health interventions for improved small ruminant production	
Lead scientist(s)	Augustine Ayantunde	Institution: ILRI
Other scientist(s)	Hamidou Nantoume, Bougouna Sogoba	
Student(s)	Clarisse Umutoni	
Location(s)	Sirakele and Zanzoni (Koutiala district)	

Procedures

Sub-activity RT3-Ma-3.1: Feed and health interventions for improved small ruminant production

It has been demonstrated that simple interventions involving disease control, improved nutrition and better management lead to marked positive effects on small ruminant performance and productivity. This activity will consist of feed supplementation and application of health care measures to sheep and goats, and will be compared to the farmers' practices as a control. The feed supplement will be 300g concentrate based on locally available agro-industrial products while the health measures will include vaccination against PPR and Pasteurellosis and deworming using Ivermectin. Five farmers each will be selected in each community for the control and the treatment (feed and health interventions) making 20 farmers in total in Sirakele and Zanzoni. The farmers to be selected should have at least 6 sheep and or goats. Data will be collected monthly on animal weight, and births and deaths among the experimental flocks will be monitored. Cost-benefit analyses will be also conducted to assess the profitability of feed and health interventions. In addition farmers will be trained in conservation and improvement of crop residues. Farmers will be selected to include at least 50% women.

Data collection: Live weight changes of sheep and goats for selected farmers, economic data.

Deliverables

	Date (2016)
7 Report on feed-health interventions for improved small ruminant production	January 2017

4. Expected outcomes

	2014	2015	2016
1. Productivity of sheep and goat improved			x
2. More men and women farmers are using food/feed crops as feed		x	x
3. Farmers are using the mobile fodder chopper to improve feeding of livestock		x	x
4. Communities are managing their natural resources without conflict		x	x

5. Budget (US\$x1000)

Theme/Activity		ICRISAT	IER	ILRI	AMEED
RT3-Ma-1	Personnel	7.5	2.5		2.5
	Services	2.5	2.5		0.5
	Supplies		2		0.5
	Travel				1.5
	Sub total	10	7		5
	Overhead	1.58	1.106		0.769
	Total	11.58	8.106		5.769
RT3-Ma-2	Personnel			49.56	
	Services			16.38	
	Supplies			7.40	
	Travel			7.47	
	Sub total			80.81	
	Overhead			12.7679	
	Total			93.577	
RT3-Ma-3	Personnel			18	
	Services			12	
	Supplies			10	
	Travel			5	
	Sub total			45	
	Overhead			7.11	
	Total			52.11	
Grand total		171.164			

Theme 4: Land, soil and water management (RT4-Ma)

1. Research team

<i>Name</i>	<i>Institution</i>	<i>Degree</i>	<i>Research interest</i>	<i>Role</i>
Birhanu Zemadim	ICRISAT	PhD	Watershed Management,	Leader, RT4-Ma-1, 4, 5
Ramadjita Tabo	ICRISAT	PhD	Agronomy	Monitoring
Mary Ollenburger	WUR	MSc	Farm systems research	Graduate student
Kalifa Traore	IER	PhD	Water and soil	Watershed activities
Mahamadou Dicko	ICRISAT	MSc	Technology Parks	Coordination
Karamoko Traore	ICRISAT	MSc	Technology Parks	Coordination
Bougouna Sogoba	AMEDD	MSc	Biomass assessments	Contact local partner
Katrien Descheemaeker	WUR	PhD	Modeling/farming systems	Modeling intensification
Gilbert Dembélé	AMEDD	MSc	Biomass assessments	Technician
Cedrick Guedessou	ICRISAT	MSc	Watershed management	Research assistant
Marc Traore	ICRISAT	BSc	Organizational	Negotiation
Gumma Krishna	ICRISAT	PhD	GIS and RS	Watershed development

2. Objectives

- 1 Determine pasture biomass at the village level and map grazing routes by village herds
- 2 Identify and characterize watersheds and their communities for sustainable agricultural intensification
- 3 Identify appropriate NRM options and use models to study their impact at different scales
- 4 Model intensification and land use at the village level using participatory approaches
- 5 Conducting participatory research at defined technology park areas
- 6 Integration of multiple research activities at technology park areas to improve institutional engagement

3. Activities

Activity RT4-Ma-1	Determine pasture biomass at village-level and map grazing itineraries
Lead scientists(s)	Birhanu Zemadim Institution: ICRISAT
Other scientist(s)	Gilbert Dembélé, Bougouna Sogoba
Student(s)	Mary Ollenburger
Location(s)	Bougouni District

Sub-activity RT4-Ma-1.1: Mapping of grazing itineraries

In order to complement the assessment of available feed resources at village level, utilization patterns must be established. To this end information on herd composition and grazing itineraries will be collected for 10 village herds in the villages of Sibirila and Dieba. Animal numbers, types, ages, and gestational status will be recorded and movements will be tracked using GPS collars throughout one year to estimate pasture utilization and pressure on grazing resources in different parts of the village territory. This information will help people make informed decisions about use of

pasture resources. Thus information from this activity can contribute to reinforcing local conventions.

Data collection: GPS and time data

Deliverables		Date (2016)
1	Data from biomass assessment and herd tracking will be uploaded to CKAN	Dec
2	Manuscript on Ecosystem services from rangelands submitted for publication	Dec
3	Report on feedback on biomass assessment results through 2015 with farmers	May

Activity RT4-Ma-2	Establish and characterize watersheds for integrated research
Lead scientist(s)	Birhanu Zemadim Institution: ICRISAT
Other scientist(s)	Kalifa Traore, Gumma M Khrishan, Cedrick Guedessou, Marc Traore, Mahamoudu Dicko, and Karamoko Traore, Bougouni Sogoba Oumar Samaké
Student(s)	Mary Ollenburger
Location(s)	Bougouni and Koutiala District

Procedures

Sub-activity RT4-Ma-2.1: Establish and characterize two technology parks for integrated research

Two Technology Parks (one in Bougouni District and the other in Koutiala District) will be identified within the Africa RISING action village areas to integrate multiple activities, and to identify major researchable issues that require integration of different research components. It is expected that activities will be worked to produce a common output. In establishing the technology park area several social and biophysical characteristics will be taken into account. For example the willingness of communities to be part of the research program is a priority concern. Thus approval from the local government authorities and local village elders is important. Physiographic characteristics namely presence of elevation, different agronomic practices (rainfed, small scale irrigation systems, land, labor, market will be considered). Two more technology parks are established in the year 2016, each in Bougouni and Koutiala. The criteria used to choose Flola and M'pessoba technology parks in the year 2015 will be valuable for this new sites identification.

Data collection:

- Existing data on local farming practices, water uses, traditional land and water management activities
- Physiographic characteristics that include drainage density, slopes
- Agro-hydrological characteristics including climatic conditions, land use and land cover pattern and soil nutrients

Based on the collected data existing eco-system functions involving benefits that build up from the use of an integrated management of natural resources capital are evaluated in the watershed program. Local land and water management interventions at both farm and community (watershed level) are mapped using GPS to characterize the spatial extent of natural resources management in the watershed. This activity generates evidence on the current NRM to support the information needed in sub-activities RT4 Ma-2.3 and RT4 Ma 2.4. The traditional practices in NRM will be closely aligned with the identification, validation and strengthening of local conventions. The activity is continuous and data is collected in the year 2016.

Sub-activity RT4-Ma-2.2: Farmers training on contour bund technology (CBTs)

At least two CBT trainings will be organized (one in Koutiala District and one in Bougouni District). Contour Bunding Technology (CBT) has been widely applied in few regions of Mali since 1995 as an effective land and water management intervention. There are existing potentials to further intensify its application which requires training farmers on its use and practices to improve household incomes and conserve the resource capital. At least two CBT trainings will be organized (one in Koutiala and one in Bougouni) in close collaboration with IER and AMEDD. The current activity will be aligned with the social and biophysical characteristics of the R4D platforms developed in Koutiala and Bougouni districts. With the inclusion of two new technology parks and need to engage more farmers in the research program (for scaling), two trainings on CBT will be organized in 2016 for both districts, Bougouni and Koutiala, with the help of AMEDD and IER. The training on CBT is conducted every year to increase awareness among the rural communities on better management of natural resources. Every year data will be recorded on the number of CBT adopters.

Sub-activity RT4-Ma-2.3: Experimentation on appropriate land and water management technologies

Contour Bunding Technology (CBT) has been widely promoted as a sustainable land and water management technology in Mali. Benefits including runoff control and prevention of soil erosion and extension of crops growing period were the main targets of the CBT applications. However since its application there are limited research activities to understand its impact on water runoff, erosion, crop productivity and ecosystem services. Data collected from the two technology parks in 2015 revealed that there is a reduction of surface runoff by 60% in farm fields treated with CBT. Therefore it is planned to do more experiment on the CBT technology in few Africa RISING villages and integrate other programs for example the farm/field level intensification options. The experimentation will be done in the identified watershed where part of the watershed area will be treated for CBT and part of the area is reserved for control. In the treatment and control portions various crop intensification options for example levels of fertilizer/manure applications, crop varieties, treatments and management options will be studied to understand the changes in crop yield, biomass and fodder productivity and the gains in eco-system services. Similarly monitoring stations (runoff, soil moisture, sediment, ground water level) will be established in both control and treatment and the changes in biophysical and eco-system conditions will be monitored in close collaboration with local communities. Here communities will be trained in participatory monitoring skills. Hence output of the CBT practices will be experimented through biophysical monitoring and crop productivity. Monitored data in terms of changes in water level in identified boreholes and streams outlet locations, soil moisture status, erosion and sedimentation rates provide biophysical impacts of CBT interventions in the watershed. Similarly crop yield, biomass, regeneration of vegetation will be monitored both at control and treated watershed to quantify the impact of intervention.

Spatial data will be mapped using GIS and data analysis help to characterize the *in situ* water use efficiencies, land degradations and intensification options for crop productivity status from farm to small watershed scale. Similarly, the various crop intensification options under technologies of land and water management will support the development of scenarios for modeling. The activity will look in to efficiency of farm systems under various intensification options. The activity started in 2015 agricultural season and need to continue for 2016. Improved data quality is expected from the 2016 agricultural season to make reliable statistical analyses. Practically farm fields will be divided in two parts and four set of equipment for runoff and erosion measurement will be installed. In the first part ridges will follow the contour lines referred to contour bundling (CB) when in the second neighboring plot traditional farmer practices (NCB) will be implemented as a control. Two replications will be implemented in the contour lines plot and two other in the control. The two parts will be homogeneously managed concerning all field operations and crop species.

Data collection:

- Soil and water samples to assess sediment and nutrient eroded
- Soil moisture in each of the CB and NCB plot to follow up water vertical distribution according to management practices in Flola and M'pessoba
- Water table measurement will be performed and two more measurements points will be installed for data accuracy and representativeness
- Continuation of soil study (pedology, toposéquence description etc.) through the works of graduate students

Sub-activity RT4-Ma-2.4: Modeling from field to watershed level using biophysical model

Various farms to small scale watershed intervention outputs will be combined to develop appropriate natural resources management practices. Information obtained from the baseline reports, field investigations and experimental analysis will be modeled using the Soil and Water Assessment Tool (SWAT) model. Apart from evaluating the farm level biophysical gains due to improved soil and water management practices, the model simulates the Blue and Green Water and help to simulate the gains in biophysical settings due to intervention options on land and water management practices. The model also simulates crop productivity under various land and water management options. Monitored data from the watershed will be used to calibrate and validate the model. The validated model will be used to develop various scenarios that help to intensify the farm/watershed scale intervention of land and water management. Hence impacts of land and water management practices will be established at a scale which is appropriate to intensify agricultural productivity in the study region. Data collected in the year 2015 has been useful to set-up the model. However biophysical data collection needs to continue for the year 2016 to have a reliable dataset that would help to validate the model.

Deliverables

		Date (2016)
1	Paper on prioritization of water sheds using remote sensing and GIS published	Dec
2	Paper on socio-economic characterization of Africa RISING sites submitted	Nov
3	Paper on shallow wells the untapped resources for food security published	Jul
4	Report on experimental results on improved land and water management	Dec

5	2015 database on soil moisture, rainfall, runoff and sediment yield uploaded on CKAN	May
6	2016 database on soil moisture, rainfall, runoff and sediment yield uploaded on CKAN	Dec

Activity RT4-Ma-3	Model development pathways and land use at village level	
Lead scientist(s)	Birhanu Zemadim	Institution: ICRISAT
Other scientist(s)	Katrien Descheemaeker	
Student(s)	Mary Ollenburger	
Location(s)	Bougouni District–Sibirila and Dieba villages	

Procedures

In Sikasso Region there are strong interactions both among farms and between farms and the surrounding non-cropped areas. Therefore it is important to integrate farm-scale intensification and larger-scale land use and natural resource management, to assess potential impacts of technologies and institutions. Data collected in activities RT4-Ma-1& 2 will be utilized to develop agent based models. These models integrate biophysical and social system components and serve as tools for informing discussion of scenarios for system change. Summary models of farm system components and processes in non-cropped areas will be based on results from field trials, farm characterization (WUR situation analysis), and biomass assessment grazing itineraries. Scenarios for possible futures will be developed in workshops with farmers and key stakeholders. Technology options as well as institutional innovations will be explored under these scenarios. This will allow us to explore possible effects of integrating farm-scale technologies with scenarios involving strengthened local conventions and improved management of natural resources at larger scales. Participatory modeling approaches will be used to explore ways to minimize trade-offs between improving farm production and farmer livelihoods and conserving natural resources. Workshops will be held in Sibirila and Dieba prior to the 2016 growing season to jointly create scenarios for modeling. Results of modeling will be presented at workshops in the same villages in September and reported to platforms.

Deliverables		Date (2016)
1	Report on workshops for generating scenarios with farmers	May
2	Report on workshops for reporting scenario modeling	Sep

Activity RT4-Ma-4	Mapping land use/land cover (LULC) and temporal changes in LULC-dynamics	
Lead scientist(s)	Gumma Murali Krishna	Institution: ICRISAT
Other scientist(s)	Birhanu Zemadim	
Location(s)	Sikasso Region	

Procedures

Using high resolution spatial data and ground based truthing the following activities will be executed.

Sub-activity RT4-Ma-4.1: LULC mapping and quantify changes temporally

Land use and land cover mapping using LANDSAT 8, 16 day repeat imagery along with MODIS @ 250mts 8 day composites. With extensive ground information and advanced classification techniques, accurate LULC maps can be generated for the Sikasso Region.

Data collection: Satellite imagery data, field information (ground reference data) and farmer interviews at selected locations and collection of validation points.

Sub-activity RT4-Ma-4.2: Impact of adoption of NRM technologies

Adoption of NRM technologies suitable for the location triggers changes in the biophysical environment which may be positive or negative. The impact of these technologies will at the same time, facilitate the targeted objectives. Remote sensing and GIS tools can be used to quantify the impact of adoption of these technologies.

Data collection: Temporal crop lands and its changes during 2013-15, evidence for impact of interventions at field level

Sub-activity RT4-Ma-4.3: Biomass estimation using Normalized Difference Vegetation Index (NDVI)

Biomass will be estimated using multi-spectral data from LANDSAT 8 and MODIS imagery. Biomass sampling will be carried out on the selected fields during the crop season.

Data collection: Crop type mapping data along with other land use/land cover information, biomass data (standard protocol to be followed)

Sub-activity RT4-Ma-4.4: Water shed prioritization for agriculture development

Prioritization of watersheds involves selection of appropriate spatial data layers relevant to agriculture development, development of criteria based on the importance of selected layers, delineating watersheds using elevation data, selection of high priority watersheds.

Data collection: Critical spatial data layers that include population, soil, drainage density, slope etc.

Sub-activity RT4-Ma-4.5: Assessing impact of upstream interventions in downstream watersheds

Assessing land use/land cover changes in downstream watersheds using satellite imagery temporally due to upstream interventions.

Data collection: Ground survey data in upstream and downstream locations, data on temporal remote sensing imagery

Sub-activity RT4-Ma-4.6: Groundwater potential zones for water resources management

Delineating groundwater potential zones using relevant spatial data layers derived from primary data and satellite imagery.

Data collection: Most critical spatial data layers needed for mapping groundwater potential zones, data on ratings and weightages to spatial data layers based on the literature and expert knowledge, spatial data layers that help to assess map groundwater potential zones

Deliverables

- 1 Report on delineated groundwater potential zones
- 2 Report on Assessment of impact of upstream interventions in downstream watersheds

Date (2016)

Dec

Dec

4. Expected outcomes

- 1 Farmers are adopting improved technologies to improve traditional farming
- 2 Communities are managing their natural resources without conflict
- 3 Scientists are validating and adapting the models developed

2014**2015****2016**

x

x

x

x

x

x

x

5. Budget (US\$x1000)

Theme/Activity		ICRISAT	IER	AMEED
RT4-Ma-1	Personnel			
	Services			
	Supplies			
	Travel	1.5		
	Sub total	1.5		
	Overhead	0.237		
	Total	1.737		
RT4-Ma-2	Personnel	30	10	15
	Services	9	10	7.5
	Supplies	10	10	7.5
	Travel	8.02	10	10
	Sub total	57.02	40	40
	Overhead	9.009	6.32	6.32
	Total	66.029	46.32	46.32
RT4-Ma-3	Personnel			
	Services			
	Supplies	0.19		
	Travel	13.83		
	Sub total	14.02		
	Overhead	2.215		
	Total	16.235		
RT4-Ma-4	Personnel	10		
	Services	2		
	Supplies	1.5		
	Travel	2.48		
	Sub total	15.98		
	Overhead	2.525		
	Total	18.505		
Grand Total		195.164		

Theme 5: Nutrition, food storage, value addition and mycotoxin management (RT5-Ma)

1. Research team

<i>Name</i>	<i>Institution</i>	<i>Degree</i>	<i>Research interest</i>	<i>Role</i>
Caroline Makamto Sobgui	AVRDC	PhD	Public health/nutrition	Leader, RT5-Ma-1,2
Toure Fatimata Maiga	IER	BSc	Technology transfer	RT5-Ma-2
Honafing Diarra	AVRDC	BSc	Nutrition	RT5-Ma-1
Pierre Coulibaly	AMEDD	BSc	Animal nutrition	RT5-Ma-1, 2
Aliou Coulibaly	IER	BSc	Food processing	RT5-Ma-2
Fatimata Cissé Diallo	IER	PhD	Food processing	RT5-Ma-1,2
Diabate Morimouso	IER	BSc	Technology transfer	RT5-Ma-2
Doumbia				
Salimata Sidibé Coulibaly	IER	PhD	Food processing	Leader, RT5-Ma-1,2
Yara Dembele Koureissi	IER	PhD	Nutrition	RT5-Ma-2
Awa Konaté	AVRDC	BSc	Nutrition	RT5-Ma-1

2. Objectives

- 1 Improve women's nutrition knowledge through nutrition field schools
- 2 Evaluate options for improving the dietary diversity of households
- 3 Evaluate post-harvest storage technologies

3. Activities

Activity RT5-Ma-1	Evaluate strategies for improving household nutritional diversity in Mali
Lead scientist(s)	Caroline Makamto Sobgui Institution: AVRDC
Other scientist (s)	Honafing Diarra, Fatimata Diallo Cissé, Pierre Coulibaly, Salimata Sidibé, Awa Konaté, Fatimata Cissé Diallo
Location(s)	Koutiala District

Procedures

Sub-activity RT5-Ma-1.1: Improving nutritional knowledge of community and extension workers
Community volunteers, agriculture and health and nutrition workers in the intervention communities will be trained in 'Behavior Change Communication' (BCC) in nutrition and health. This will equip community workers with the technical, action-oriented knowledge and counseling skills needed to support pregnant women, breast-feeding mothers with children less than two years of age and other key family members to adopt nutrition practices. Refresher training to recall and reinforce of previously acquired knowledge and skills will be organized every six months.

Sub-activity RT5-Ma-1.2: Evaluate strategies for improving household nutritional diversity
Activities and data collection to evaluate strategies for improving household nutrition security started in 2015 will continue in Koutiala while they will be initiated in Bougouni District where nutrition activities were not previously implemented.

In Koutiala District, 200 hundred households with women of child bearing age and nursing mothers with children aged 6-24 months randomly selected in 2015 from intervention communities will continue to be followed to assess the impact of providing community nutrition trainings on adoption of improved nutrition practices for young children. At least 100 households have been randomly assigned to one of the following treatments:

1. Behavior change communication training on nutrition and agriculture support in vegetables, legumes and cereals
2. Agriculture support in vegetables, legumes and cereals

Extension workers will conduct monthly BCC sessions in target communities on improved nutrition practices and home visits to counsel and support mothers and their families This will be linked with Activity RT5-Ma-2 on improving post-harvest and processing techniques.

The approach used to select beneficiaries allows identifying two groups of beneficiaries, notably primary and secondary beneficiaries. Primary beneficiaries are those women who are trained by project staff and will receive seed kits; they will agree, in their turn, to transfer the acquired knowledge to the secondary beneficiaries who will also receive seed kits. This aimed to equip women of child bearing age and specially lactating mothers with children below aged 6-24 months and pregnant women with knowledge and skills to foster adoption of proper health care and nutritional practices.

Women will be organized in nutrition support groups which gather twice each month at the village level to discuss their experiences and learn better practices in child care, feeding, health, and sanitation, gardening and small livestock rising. Nutrition Club meetings will be facilitated by a trained community worker. The establishment of nutrition support groups will be facilitated by the project team by providing essential cooking materials.

Separate sensitization meetings with community leaders, fathers and grandmothers will be conducted every two months to foster community mobilization and create and strengthen an enabling and supportive environment for behavior change. Data on young child nutrition practices including initiation of complementary feeding, breastfeeding practices, dietary diversity scores, frequency of feeding, type of foods/fluids, hygiene practices and responsive feeding practices will be collected every three months to monitor behavior change and adoption of good practices

A cluster non-randomized controlled trial will be used to collect quantitative and qualitative data on dietary diversity score, Knowledge, attitude and practices primary data from mother/child pairs. This means **a controlled** pre-test/post-test design involving two cross-sectional surveys at baseline and end point follow-up will be used to determine the outcome/impact of the program. **This will involve making** observations before and after the implementation of the intervention.

Comparison of selected indicators at baseline and at end of project will give an indication of changes that have taken place with time. Additionally, a comparison between intervention and control communities will show the changes which can be attributed to the program interventions.

Deliverables		Date (2016)
1	Report on dietary diversity of households in the intervention areas	Aug
2	Report or publication on the number of people trained in improved nutrition practices and the number of nutrition support groups established and functional	Aug
3	Reporting of about 200 farmers trained in intensive vegetable post-harvest management and nutrition techniques	Sep
4	Manuscript on strategies to improve nutrition practices in Southern Mali will be prepared and submitted for publication in a peer-reviewed journal	Dec
5	Gender-disaggregated data on nutrition status, knowledge attitudes and practices uploaded to CKAN	Dec

Activity RT5-Ma-2	Evaluate postharvest technologies	
Lead scientist(s)	Salimata Sidibé Coulibaly	Institute: IER
Other scientist (s)	Fatimata Diallo Cisse, Yara Dembele Koureissi, Aliou Coulibaly, Diabate Morimouso Doumbia, Toure Fatimata Maiga, Caroline Makamto Sobgui	
Location(s)	Koutiala and Bougouni districts	

Procedures

Sub-activity RT5-Ma-2.1: Developing improved processing and preservation techniques using crops, legumes, vegetables and animal products

Develop complementary feeding, diversified diet for children under 24 months and women in child bearing age, as well as wide consumption products. These products will be developed based on the available local products and equipment.

This activity will continue on the development of improved processing and preservation techniques using animal products.

There will be three separate experiments using a completely randomized design in each with the following treatments (T) and controls (C):

Experiment 1:

- T1 = Malted maize flour couscous
- T2 = Malted maize flour couscous + leafy vegetables (moringa, spinach, etc....)
- C1 = Normal maize flour couscous

Experiment 2

- T3 = Malted sorghum flour couscous
- T4 = Malted sorghum flour couscous + leafy vegetables (moringa, spinach, etc....)
- C2 = Normal sorghum flour couscous

Experiment 3

- T5 = Malted millet flour couscous
- T6 = Malted millet flour couscous + leafy vegetables (moringa, spinach, etc....)
- C2 = Normal millet flour couscous

Proximate composition (protein, lipids and energy contents) of the developed products will be determined as well as iron, zinc, vitamin A, and calcium. Sensory characteristics and acceptability tests will be conducted in lab and household.

Evaluate the shelf life, storage conditions and quality of the developed products. The developed products will be stored in two different storage conditions as in the villages and in packages to add value to the products. Determine the rancidity of the developed products during the shelf life period.

Sub-activity RT5-Ma-2.2: Training women, mothers and caregivers on the developed processing preservation, and value addition techniques

The developed processing and preservation techniques will be transferred to the target group by training sessions in the Nutritional and Production Field Schools in Koutiala and Bougouni districts. Training modules will be developed for the local trainers. Knowledge and practices of dietary diversity will be included in the training modules.

Sub-activity RT5-Ma-2.3: Monitoring consumption and utilization of developed products and techniques

Monitoring of the consumption and use of the developed products will be conducted every 3 months using elaborated monitoring documents to assess the degree of utilization of the developed processing techniques. The monitoring documents will be given to local trainers in Nutritional Field Schools Production Field Schools in order to evaluate the consumption frequencies, the number of families practicing and using the developed techniques, and their utilization modes (familial and local consumption as well as sales).

Sub-activity RT5-Ma-2.4: Experimentation to evaluate the effect of new complementary feeding

The experiment will evaluate the effect of the new complementary feeding mix on the nutritional status of children from 9 – 24 months. There will be 3 groups (1 control group and 2 treatment groups: 15 children in each group). The complementary feeding mix will be made and packaged at LTA.

Data collection: (i) Proximate composition (protein, lipids and energy contents) of the developed products, (ii) micronutrient contents such as iron, zinc, vitamin A, and calcium, (iii) sensory characteristics and acceptability tests both in the lab and at household level, (iv) shelf life, storage conditions and quality of the developed products, (v) rancidity of the developed products during the shelf life period, (vi) perception of the gained knowledge and practices of dietary diversity through training program, (vii) data on consumption frequencies, the number of families practicing and using the developed techniques, and their utilization modes

Deliverables		Date (2016)
1	Manual on postharvest technologies modules and report on: Number of modules, Number of training sessions, Number of beneficiaries, disaggregated by gender	June
2	Report on monitoring of nutrition activities, documents elaborated Number of monitoring visits and beneficiaries adopting the technologies disaggregated by gender	Sep
3	Data on physical, nutritional and sensory characteristics of developed products uploaded to CKAN	Dec
4	Article on malting and fermentation to improve viscosity and energy density of complementary feeding submitted	Dec

4. Expected outcomes		2014	2015	2016
1	Women are putting into practice knowledge from nutrition field schools	x	x	x
2	Households are adopting behaviors that improve their nutritional status		x	x
3	Households are adopting options to reduce post-harvest losses		x	x

5. Budget (U\$x1000)

Theme/Activity		ICRISAT	AVRDC	AMEDD	IER
RT5-Ma-1	Personnel		25	6	5
	Services		10	6	0.5
	Supplies		5	4	0.5
	Travel	1	6.61	4	4
	Sub total	1	46.61	20	10
	Overhead	0.158	8.390	3.160	1.58
	Total	1.158	55	23.160	11.58
RT5-Ma-2	Personnel		1		10
	Services		1		5
	Supplies		0.737		5
	Travel	1	1.500		10
	Sub total	1	4.237		30
	Overhead	0.158	0.763		4.74
	Total	1.158	5		34.74
Grand Total		131.796			

Table 3: 2016 Mali consolidated activity-based Budget										
	Theme/Activity	Activity Leader	Tentative partner budget (US\$x1000)							
			ICRISAT	ICRAF	ILRI	AVRDC	AMEED	IER	CAAD	GRADCOM
	Partnerships and socioeconomics of intensification									
1.1	Establishment and characterization of R4D platforms	ICRAF (Binam)	3.474	59.637			23.160			
1.2	Project coordination and facilitation of activities in Tech Parks	ICRISAT (Birhanu)	28.950							
1.3	Monitor market prices and characterize value chains	ICRISAT (Badolo)	13.896					13.896		
	Intensification of cereal-legume-vegetable cropping systems									
2.1	Intensifying productivity of cereal-legume cropping systems	ICRISAT (Tabo)	13.896						9.264	9.264
2.2	Improving the productivity of vegetable cropping systems	AVRDC (Jean Baptiste)				60.000				
2.3	Agroforestry options for fruit, vegetable and fodder production	ICRAF (Catherine)		57.900						
	Intensive livestock production									
3.1	Improving feed resources production and use in mixed farming	ICRISAT (Sapna)	11.580				5790	8.106		
3.2	Document and validate existing conventions	ILRI (Augustine)			93.578					
3.3	Feed and health interventions for small ruminants	ILRI (Augustine)			52.110					

	Land, soil and water management									
4.1	Determine pasture biomass at village level and determine grazing itineraries	ICRISAT (Birhanu)	1.737							
4.2	Establish and characterize watershed for integrated research	ICRISAT (Birhanu)	66.029				46320	46.320		
4.3	Model development pathways and land use	ICRISAT (Birhanu)	16.250							
4.4	Map land use changes	ICRISAT (Gumma)	18.508							
	Nutrition, food storage, value addition and mycotoxin management									
5.1	Evaluate strategies for improving household nutritional diversity	AVRDC (Caroline)	1.158			55.000	23.160	11.580		
5.2	Reducing post-harvest losses in stored grains	IER (Salimata)	1.158			5.000		34.740		
		Total	437.187	117.537	145.688	120.000	98.430	114.642	9.264	9.264
		Grand total					1052.012			